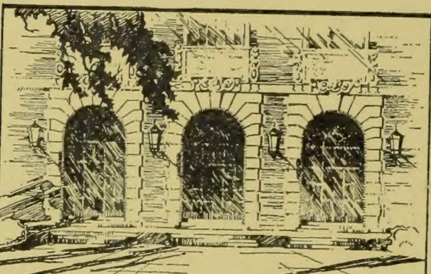

THE

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OF THE

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CONTENTS.

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SCIENTIFIC TRANSACTIONS

OF THE

ROYAL DUBLIN SOCIETY.

VOLUME IV.

I.

ON FOSSIL-FISH REMAINS FROM THE TERTIARY AND CRETACEO-TERTIARY FORMATIONS OF NEW ZEALAND. By JAMES W. DAVIS, F.G.S., F.L.S., &c. (Plates I. to VII.)

[Read December 14, 1887.]

(Communicated by E. Perceval Wright, M.D.)

I.—INTRODUCTORY.

More than two years ago I received a request from Capt. F. W. Hutton, Professor of Biology at Canterbury College, Christchurch, that I would describe the remains of some Tertiary elasmobranchs found in New Zealand. This was speedily followed by a small collection of fish-remains, which formed the subject of a Paper read at the Geological Society, London. Immediately after having made this communication, I received an intimation that other and larger collections had been forwarded, and, with the permission of the Council of the Geological Society, I was allowed to withdraw the Paper. The private collection of J. Davies Enys, Esq., afforded some beautiful examples, collected from the Castle Hill Station, near Canterbury. Prof. T. J. Parker sent a number of specimens from the Otago Museum, collected by H. A. Ingles, Esq., from the Amuri limestone of Kaikoura. Other examples obtained from the same strata by Mr. Ingles were selected from the Museum of Canterbury College, Christchurch, and forwarded by Prof. F. W. Hutton. To Sir Julius von Haast, whose premature

death we have now to lament, I am especially indebted for the loan of a very large and important collection, consisting of many hundreds of specimens from the Canterbury Museum, Christchurch; I am further personally indebted to Sir Julius for much valuable information, freely and generously imparted during his visit to this country as Commissioner in connexion with the Colonial and Indian Exhibition at South Kensington. I wish also to express my thanks to Mr. Cheeseman of the Auckland Museum, and to Sir James Hector, Director of the Wellington Museum, who has charge of the Geological Survey collections. The latter kindly referred me to a collection he left at the British Museum in 1876, and forwarded the collections, consisting of a large number of specimens from the Colonial Museum of New Zealand at Wellington, made in connexion with the Geological Survey of the country. As on many previous occasions, it is a pleasure to acknowledge the courtesy and kind attention always accorded by those in charge of the National Collections at the British Museum, Natural History Department; and to Dr. Henry Woodward and Robert Etheredge, Esq., I tender my thanks; to A. Smith Woodward, Esq., I am greatly obliged for much painstaking and most useful help.

II.—THE TERTIARY FORMATIONS OF NEW ZEALAND.

In Europe, the close of the cretaceous period was marked by a more or less complete break in the chain of animal life: the forms, characteristic of the chalk formation, were to a large extent replaced by others prior to the deposition of the tertiary strata. These changes imply a long period, during which the areas occupied by the cretaceous seas were raised so as to form shallower marine areas, estuaries, or land. The chalk suffered an immense amount of denudation. In England and the whole of the European area the break between the cretaceous and succeeding strata of Eocene age is one of the most important and clearly marked in the geological sequence of stratigraphical rocks. In other parts of the world the change from the secondary to the tertiary formation is gradual; and in some instances no clear line of division, on palæontological grounds, can be maintained. In the United States the sequence is unbroken, and the Laramie group of estuarine beds is regarded as holding an intermediate position between the two, its large fauna and flora exhibiting a transitional stage. The flora is of Eocene character, and taken together with the lacustrine constitution of the strata confirms the determination to place it with the tertiaries. The fauna, on the contrary, is of a mixed character, the Dinosauria are Mesozoic, and have not hitherto been found in tertiary strata; whilst turtles and crocodiles, along with some genera of fishes, like Clastes and Myledaphus, are equally of tertiary types. In America the changes of level were less rapid, and extended over much larger

areas than in Europe, and the result has been that the changes in the fauna have been made with comparative regularity, and the violent dislocations so characteristic of the European series have been avoided. In India the tertiary strata attain a vast thickness; in Scind the Oligocene and Miocene formations together exceed 10,000 feet in thickness, the lower beds consisting of nummulitic limestones, and presenting a marked distinction from the chalk. The lower parts are rich in mammalian remains, and similarly to the tertiary strata of America, throw considerable light on the ancestral derivation of some of the existing species. The transition in the New Zealand strata is probably somewhat dubious. The Oamaru and Pareora formations are undoubtedly tertiary; the succeeding formation in descending order, the Waipara, is considered by the Geological Survey to be composed of strata of transitional Cretaceo-tertiary age, whilst Professor F. W. Hutton and Sir Julius von Haast regard the unconformity between the Waipara and Oamaru as sufficiently distinct and important to render necessary the consideration of the former group as upper cretaceous.

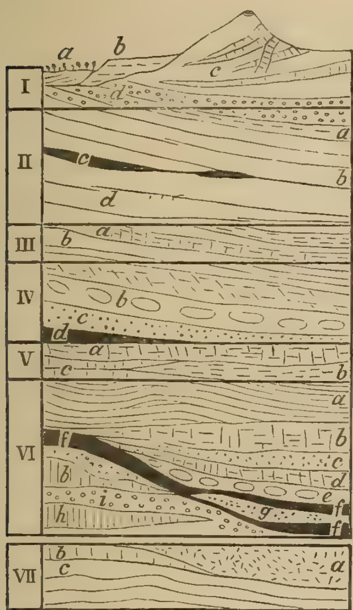
It is difficult to draw arbitrary lines between divisions in sedimentary rocks which shall correspond to palæontological distinctions calculated to be of any permanent value. The development of species, if accepted as a reliable theory, naturally infers changes in specific characters, which point to faunal distinctions as ephemeral, and stratigraphical epochs and periods founded on such distinctions are liable to constant modification in consequence. Besides the evolutionary process which affects the faunal characteristics of any given locality, there is further difficulty in correlating beds, with any degree of certainty, occurring in widely separated areas, because, though the strata may be as nearly as possible of the same age, and more or less similar in character, the fossil contents exhibit remarkable differences. Certain important groups which are characteristically associated with the strata of one district may be entirely absent from that of another of the same age; thus, the saurians and fish, so abundant in the Lias of Britain, are unknown in American strata, whilst the beautiful series exhibiting the ancestry of the horse found in the American tertiaries has no representative in England; on the other hand, again, the avian derivatives of Solenhofen and the English Eocene are unknown to the strata of America. Instances might be multiplied to an almost indefinite extent in every quarter of the globe. Taking this view of the question, and bearing in mind that increase of knowledge makes deductions from an evolutionary basis, a constantly changing quantity, it appears to be a rational plan to follow the method for classifying strata as stated by Prof. Hutton ("Quart. Journ. Geol. Soc.," vol. xli., p. 192) in the following terms:—"The geology of a district can be studied quite irrespective of any other part of the world; we can group its rocks by means of unconformities (stratigraphical and palæontological) into systems and series, and after having made out its geological history, we can compare it with that of other parts of the world

by endeavouring to refer the systems and series to their probable equivalents in Europe." This is essentially the plan adopted in the United States and Canada, as well as in the different countries of Europe, and by English geologists in India.

The following is the list of formations from the cretaceous upwards, for which I am indebted to a paper by Professor F. W. Hutton, on the Geology of New Zealand, in the "Quarterly Journal of the Geological Society," vol. xli., p. 194:—

Recent,	Alluvian and Æolian deposits with Moa-bones and traces of Man,	RECENT.
Pleistocene,	Raised Beaches and shore deposits, Peat mosses, with bones of Moa,	PLEISTOCENE.
Wanganúi System,	Kéreru series, Ormond series, Pétane series, Pútiki series,	NEWER PLIOCENE.
	Older Glacial Deposits, Lignites of Otágo, Mauukau, &c.,	OLDER PLIOCENE.
Pareóra System,	Awatére series, Kauieri series, Táwhiti series, Ahuríri series, Waitemáta series, Brown Coal of Pomahάka, &c.,	MIOCENE.
Oamarú System,	Mt. Brown series, Aotéa series, Ototara series, Turanganúi series, Coals of Waíkato, Kaitangata, &c.,	OLIGOCENE.
Waipara System,	Amuri series, Awanui series, (?) Matakéa series, Coals of Graymouth, Pakawan, &c.,	UPPER CRETACEOUS.

The classification adopted by the Geological Survey Department differs from this one in several particulars, and for the purpose of comparison it is given here; it is taken from the Guide to the New Zealand Geological Exhibits at the Indian and Colonial Exhibition, London, 1886, and was prepared by Sir James Hector, C.M.G., F.R.S., &c., Director of the Survey :—



I. Post-Tertiary and Recent—
a. Alluvial. *b.* Turbary. *c.* Volcanic. *d.* Dispersed gravels.

II. Pliocene—
a. Dispersed gravels. *b.* Napier series. *c.* Lignite series. *d.* Kèreru series.

III. Upper Miocene—
a. Te Aute series. *b.* Taueru series.

IV. Lower Miocene—
a. Awatere series. *b.* Pareora series. *c.* Awamoa series.

V. Upper Eocene—
a. Mount Brown series. *b.* Oamaru series. *c.* Waitaki series.

VI. Cretaceo-tertiary—
a. Waitemata series. *b.* Ototara series. *c.* Mawhera series. *d.* Chalk series. *e.* Waireka series. *f.* Coal series. *g.* Black grit series. *h.* Propylite breccia series. *i.* Great Conglomerate series.

VII. Lower Greensand—
a. Buller series. *b.* Porphyry breccia series. *c.* Amuri series.

The fish-remains described in this memoir are from the Waipara, Oamaru, and Pareora systems; they are comprised, with one or two exceptions, of sharks and rays; they number, of the former, twenty-four, and of the latter, four; besides there is one teleostean, a Sparnodus. There is also one species of whale; a Squalodon. Of the elasmobranchs, two species of Carcharodon and one of Notidanus have been previously described by Agassiz, and are of world-wide distribution in tertiary strata. Several of the species of Oxyrhina and Lamna approach nearly to some of the European forms; but whilst recognizing their relationship, reasons are given why they should be considered rather as separate species than allocated with those previously described. There is, perhaps, no group of fossil-fishes which have had so wide a geographical range as the larger sharks, and it is consequently of especial interest to consider those of formations scattered over the world, and to compare them with the representatives from the systems of New Zealand. In Australia the remains of large sharks have been found. Professor Frederick M'Coy has recorded and described two species—*Carcharodon angustidens* and *C. megalodon*—from the Miocene Beds of Bird Rock, near Geelong ("Prodromus Palæont. of Victoria," Decade ii.,

pl. xi., figs. 2, 3); and the Rev. J. E. Woods ("Geol. Obs. in S. Australia," p. 80) records the occurrence of teeth of Oxyrhina and probably Lamna.

Some remains of selachians have been recorded from the tertiary strata of India, principally fragments of Carcharodon and Myliobatis. Sir Philip Egerton described a series of the teeth of sharks from the Pondicherry Beds, consisting of two species of Corax, five of Otodus, one of Oxyrhina, two of Lamna, and two of Odontaspis ("Quart. Journ. Geol. Soc.," vol. i., p. 164). The presence of Corax, a genus restricted to the chalk, and the relationship of the other species to those already known from the chalk, led Sir P. Egerton to consider the Pondicherry Beds of cretaceous age.

In Europe the tertiary strata cover a wide area, and are of great importance. The "Faluns" of France, the Swiss "Molasse," and the "Crags" of England and Belgium, are of Pliocene age; they are also largely represented in Italy. The cities of London, Paris, Vienna, and Berlin, are built on "Basins" of Oligocene or Eocene strata. The selachian remains found in these beds have received considerable attention from palæontologists; more particularly may be named the recent researches of F. Noetling* in North Germany, Dr. H. B. Geinitz† in Belgium, H. E. Sauvage‡ in the north of France, Dr. J. Probst§ in the Baltringen district, and R. Lawley|| in Italy.

In the list of fossils from the New Zealand strata there are eight genera of elasmobranchs, which are all found in the tertiary strata of the Oamaru formation. Of these five are also obtained from the cretaceous of Waipara, but in each instance they have been got from the uppermost beds of that system. In the European strata a parallel set of circumstances is found to prevail. The genera Galeocerdo, Oxyrhina, Lamna, Odontaspis, and Notidanus, which are found in both the Waipara and the Oamaru formations, range through both the cretaceous and tertiary systems in Europe. Of the remaining three genera, viz. Carcharodon,

* F. Noetling, "Abh. Geol. Specialk. Preussen u. Thüring. Staaten," vol. vi., pt. 3, 1885. Haifischzähne in "Sitzungsb. Gesells. naturf. Freunde." Berlin. Jahr. 1886, pp. 13–17.

† H. B. Geinitz, "Abh. Gesell. Isis in Dresden," 1883. Koprolithenlager von Helmstedt, &c., pp. 3–9, 38–39, 108, 109.

‡ H. E. Sauvage, "Memoirs Soc. Sci. Nat. Saône et Loire," 1880, pt. 1, pls. i., ii. Selachians from "Faluns de Bretagne."

§ J. Probst, "Jahreshefte in Würtemberg," vols. xxxiii. (1877), p. 69, pls. i., ii. Beiträge zur Kenntniss der fossilen Fische aus der Molasse von Baltringen—continued in vol. xxxiv. (1878), p. 111, pl. i.; and vol. xlii. (1886), p. 301, pl. ix.

|| R. Lawley, Resti fossili della Selache trovati a Ricava presso santa luce nelle collem Pisano, "Atti della Societa Toscano," vol. iv., p. 105. Nuovi denti fossili di Notidanus rinvenato ad Orciano Pisano, *op. cit.*, p. 196.

Trygon, and Myliobatis, the two former in Europe do not extend beyond the tertiary formations, but in New Zealand are found in the Waipara. The last genus is confined to the Oamaru formations, and has not been found below the tertiaries in Europe. Species of the genus Sparnodus occur in the chalk as well as in the tertiaries in Europe, but in New Zealand they are confined to the Oamaru formation.

A complete list of the fish remains, with the formations from which they have been obtained, will be found at the close of the description of the species.

In addition to the fish and whale remains there are instances of the occurrence of teeth of saurians; they are mostly in a fragmentary condition, and have been found in several localities on different horizons. The largest tooth was found by Mr. J. Stephenson at Waitaki; another, representing only the base, was discovered by Sir Julius Von Haast in the fine breccia of Amuri Bluff, and a third in the Amuri Limestone of the Kaikoura peninsula was found by Mr. H. A. Ingles of Kaikoura.

III.—DESCRIPTION OF THE SPECIES OF FISH-REMAINS FROM THE TERTIARY FORMATIONS OF NEW ZEALAND.

Class.—PISCES. Sub-Class I.—PALÆICHTHYES.

Order 1.—Chondropterygii. Sub-Order 1.—Plagiostomata.

(A)—SELACHOIDEI—SHARKS.

Family I. **CARCHARIIDÆ.**

Genus. **Galeocerdo.** Müll. and Henle.

Teeth, flat, triangular, oblique, serrated on both edges, with a deep notch on the outer margin. Anterior surface arched; posterior surface hollowed or sloping backwards. External face flat; internal rounded. Root not very thick, conforming in outline to base of crown.

Teeth of Galeocerdo are distinguished from those of the genus Galeus, by having both the anterior and posterior margins denticulated; in Galeus the anterior margin is smooth.

The fishes of the genus Galeocerdo first appear in the chalk, they are found in the tertiary formation, and two species still exist.

Galeocerdo aculeatus, DAVIS.

(Pl. I., figs. 1–3.)

Small, beautifully-preserved teeth, with large central cone, and a lateral prolongation of the crown on each side, surmounting a widely-expanded base. The whole of the cutting edge is serrated; the serrations are larger on the lateral prolongations than on the sides of the median cone; the latter, towards the apex, is nearly smooth. The teeth differ in form, varying, from examples with the width of the base equal to the height of the crown, to others in which the base is equal to one and a-half times the height. The external surface of the medianc one is slightly convex, depressed and flat towards the base; the summit is pointed and bent slightly backwards in all the specimens. The internal surface is much more convex than the external one. The serrations on the lateral margins are irregular, the largest being in the angle, between the cone and the lateral extensions of the crown. The root is co-extensive in breadth with the crown, and has a depth equal to about half the height of the central cone. Externally the surface is concave, internally it is prominently convex with a median groove extending from the crown downwards. This species approaches most nearly to those of *Galeocerdo minor*, Agass, and *Galeocerdo latidens*, Agass, "Poissons Fossiles," vol. iii., pp. 231, 232, pl. XXVI. The latter was described by Prof. Agassiz from a specimen in the Museum at Paris, the origin of which was unknown. *G. minor* is from the tertiary of Switzerland, and differs principally in size from *G. latidens*. The species now described is readily distinguished by the greater elevation, as compared with its breadth, of the median cone, and by its being somewhat more erect.

Formation.—Oamaru formation; Awatere series.

Localities.—Coleridge Gully. Castle Hill Station, Canterbury; Mohaka Crossing, Napier.

Ex coll.—Canterbury Museum, Christchurch. J. D. Enys, Esq. and Geological Survey Collections, Wellington.

Family II. **LAMNIDÆ.**

Genus. **Carcharodon.** MÜLLER and HENLE.

MÜLLER and HENLE, 1841. "Syst. Beschreib. Plagiostom.," p. 70 (Ex Andrew Smith, M. S.)

AGASSIZ, L., . . . "Recher. sur les Poiss. Foss.," vol. iii., p. 245.

Teeth very large, compressed, triangular, without basal cavity; composed of massive dentine, with reticulated canals; margin serrated, with or without lateral cusps.

Carcharodon angustidens, AGASSIZ.

(Pl. I., figs. 4–6. Pl. VI. fig. 22.)

C. angustidens.	L. Agassiz, 1833. .	"Rech. s. l. Poiss. Foss.," vol. iii., p. 255, pl. XXVIII., figs. 20–25, pl. XXX., fig. 3.
,,	Pictet, J. F., 1845. .	"Traité de Palæontologie," vol. ii., p. 270.
,,	Giebel, C. G., 1848.	"Fauna der Vorwelt," vol. i., pt. 3., p. 350.
,,	M'Coy, F., 1875. .	"Geol. Surv. of Victoria," Dec. ii., p. 8, pl. XI., figs. 2, 3.
,,	Sauvage, H. E., 1880.	"Mem. Soc. Sci. Nat. Saône-et-Loire," pt. 1., pl. I.
,,	Geinitz, H. B., 1883.	"Abh. Naturwis. Gesell. Isis., Dresden," p. 6, pl. I., fig. 11.
,,	Noetling, F., 1885. .	"Abh. Geol. Specialk. Preussen u. Thuring, Staaten," vol. vi., pt. 3.

Three specimens attributed to this species are represented on Plate I. Whilst possessing characters which appear to indicate a close relationship, they present some features which are not identical in each. The teeth are erect, elongate, of great thickness antero-posteriorly, the lateral margins with the base forming a more or less acutely-pointed isosceles triangle; on each side the base of the crown there is a lateral denticle, the two occupying one-fourth of the total width of the tooth. The lateral margins are serrated; the serrations encircle the point as well as the lateral denticles of the tooth. The external surface between the lateral margins is convex; in the direction from the base to the point it is first convex, but nearer the apex is more or less depressed. The internal surface is highly convex, almost semicircular. The lateral denticles extend at a right angle from the margin of the central portion of the tooth. The root or base of the tooth is large, and extends on each side to a greater width than the base of the crown, from which it is separated by a line considerably less curved upwards on the external than on the internal surface. The median portion of the base on the internal surface is greatly produced, forming a prominent convex bulb, which is adapted to a corresponding concavity on the external surface of the succeeding tooth. The

lateral extremities of the base extend downwards, forming bold and firm projections for the attachment of the tooth in the jaw.

The tooth represented by fig. 4 (Pl. i.) is broader and shorter than the others, and has probably been located in the posterior part of the jaws. It is the most perfect specimen included in the series. The median length of the external face is 1·6 inch, the breadth between the extremities of the two lateral denticles is 1·9 inch; the base is 2·1 inches broad, and its depth 0·6 inch; its diameter, between the internal and external surfaces, is greatest in a line through the central convex bulb, named above, is 0·7 inch.

Fig. 5 represents a tooth from the anterior portion of the lower jaw; its form is considerably more lanceolate than that of fig. 4. Its median length is 2·0 inches from the apex of the line dividing the crown from the base to the point. One of the extremities of the base is wanting, but from the median line to the extremity of the remaining one is 0·85 inch, or for the breadth of the whole tooth 1·7 inch. The lateral extremities of the root are elongated correspondingly with the crown. The third example (fig. 6) is probably from the upper jaw, it is broader in proportion to the length than the teeth from the lower jaws, this being more especially noted near the point of the tooth. The lateral denticles are broken off, and a portion of the base has disappeared, so that its exact proportions as compared with the others cannot be recorded.

This species approaches most nearly to those figured by Agassiz, under the name of *Carcharodon auriculatus*, De Bl., "Rech. sur les Poiss. Foss.," vol. iii., p. 254, pl. xxviii., figs. 17–19, *Carcharodon angustidens*, Agass., *op. cit.*, vol. iii., p. 255, pl. xxviii., figs. 20–25, and pl. xxx., fig. 3, the latter with the name *C. lanceolatus*. Prof. Agassiz described the species from specimens existing in the Museum at Paris, Strasburg, and elsewhere, of which the original locality was unknown; but specimens have been discovered in the Tertiary strata at Kressenberg and Dax. The species now described differs from *C. auriculatus* in its robust proportions. The latter is described as comparatively thin, the external face being flat. It differs from the type figured by Agassiz as *C. angustidens*, by the great prominence of the median bulb of the root and the corresponding concavity of the opposite surface. The enamelled surface of the crown in Agassiz's specimens is divided from the root almost in a straight line, whilst in the New Zealand specimens the division extends high on the median portion of the tooth forming a deeply concave line; the lateral denticles, as compared with the median extent of the coronal surface, are situated at a much lower level in this than in the species described by Agassiz. Notwithstanding these variations in the form of the teeth, they do not appear to be of such a character as to render doubtful the position in which the teeth now described should be located, and they are included with the specimens described by Agassiz in the species *C. angustidens* without hesitation. Professor M'Coy has assented to the inclusion by Dr. Gibbes ("Monog. Squal.") of

the following species with that of *Carcharodon angustidens*, viz.: *C. lanceolatus*, *C. auriculatus*, *C. megalotus*, *C. turgidus*, *C. heterodon*, *C. semiserratus*, and *C. toliapicus*. Several of these were described by Agassiz from specimens of which the history was not known, localities were only surmised at, and it is possible that some, or even all, may pertain to one species; but without examination of all the types, and comparison with other specimens which may have been discovered during the fifty years which have elapsed since the publication of the "Poissons Fossiles," considerable caution should be exercised in accepting the determination of Dr. Gibbes.

In the collections sent by Sir J. Hector, Director-General of the Geological Survey, there is a beautiful little tooth in such an exquisitely perfect state of preservation, that it seems impossible that it can have been used. It is triangular in outline, the margins are minutely serrated, the point perfect. There is a lateral cusp presenting a rounded outline, and apparently not fully developed. The root is divided and deep, but narrower than the base of the crown. The form and characters of the tooth appear to indicate an immature example of *Carcharodon angustidens*, and it appears desirable to associate it with this species, at any rate provisionally. It is represented on Plate VI., fig. 22.

The teeth of *Carcharodon angustidens* have a world-wide distribution in Tertiary strata. In England they are found in the London clay, and in the island of Sheppey; at Antwerp, in Belgium; at Kressenberg, Dax, Helmstadt, and other places in Germany. In Westphalia numerous specimens are obtained from the Miocene Tertiary strata at Bünde. The teeth occur in the Tertiary strata of North America, and Prof. F. M'Coy has found and described examples from the Miocene sands of Bird Rock, near Geelong, in Victoria, Australia. This species and the one next following are, perhaps, the most abundant and widely distributed of all the sharks in the Tertiary strata, especially of Miocene age. The genus is represented by only one living species at the present time. The teeth of Carcharodon may be readily distinguished from those of Carcharias by the absence of the conical cavity in the base.

Formation.—Oamaru formation, and Waireka series.

Localities.—Waihoa Falls; Wekapass; Curiosity Shop; Deep Creek, Blueskin; Amuri limestone, Kaikoura Peninsula; Greymarls, Wekapass stone; Kakahu, near Canterbury (lower coal-beds); Waitaki Valley (Maraewhenna limestone); Raglan, Auckland; Amuri Bluff; Waihola Gorge; Castle Hill Station, near Canterbury; Esk River, Hawkes Bay.

Ex coll.—Canterbury and Otago Museums; J. D. Enys, Esq., and Geological Survey Collections, Wellington.

Carcharodon megalodon, Agassiz.

(Pl. ii., figs. 1–3.)

Carcharias megalodon,		L. Agassiz, 1833–43,	"Rech. s. l. Poiss. Foss.," vol. iii., p. 247, pl. xxix.
,,	,,	Agassiz, . . .	"Egerton's Catalogue."
,,	macrodon, .	,, . .	,, ,,
,,	grosseserratus.	,, . .	,, ,,
,,	megalodon,	,, 1834, .	"Verhandl. Böhm Museum," p. 66.
,,	,,	James, 1836, . .	"Edin. New Phil. Jour.," vol. xxi., p. 319.
,,	,,	,, 1837, . .	"Loud. Mag. Nat. Hist.," vol. i., p. 225, fig. 24.
,,	,,	Brown, H. G., . .	"Leth geogn.," vol. ii., p. 1163, pl. xliii., fig. 1.
,,	,,	,, ,, 1835,	"Jahrb. des Petref.," p. 740.
,,	,,	,, ,, 1837,	,, ,, pp. 494, 123.
,,	,,	,, ,, 1839,	,, ,, p. 114.
,,	,,	Philippi, . . .	"Tertiarversteinerg," p. 20.
Carcharodon megalodon.		Geinitz, H. B., 1843,	"Versteingk," p. 172, pl. vii., fig. 17.
,,	,,	Münster Graf., 1841,	"Beitrage zur Petrefact," vol. vii., p. 22.
,,	,,	Pictet, J. F., 1845, .	"Traité de Palæont," vol. ii., p. 270.
,,	,,	Giebel, C. G., 1848, .	"Fauna d. Vorwelt," vol. ii., pt. 3, p. 348.
,,	,,	M'Coy, F., 1875, .	"Geol. Surv. Victoria," Dec. ii., p. 9, pl. xi., fig. 4.
,,	,,	Sauvage, H. E., 1880,	"Mem. Soc. Sci. Nat. Saône-et-Loire," p. 1, pl. i.

Teeth very large, unsymmetrical, broader than long, triangular, without lateral cusps, cutting edges finely serrated. External surface flat or slightly concave. Internal surface convex. Upper portion of crown inclined outwardly. Line dividing the crown from the base deeply arched, especially on the internal surface. The height of the crown is 2·0 inches; right lateral margin 3·4 inches; opposite one an inch shorter. Outline of margins sigmoidal. Root same breadth as base of crown, has a depth of 0·9 inch. It is thicker than the crown, concave on the outside, and on the inner one convex. The base of the root is deeply concave, parallel with the external base of the crown.

The teeth represented by figs. 1–3 on Pl. II. are the only ones included in the collections placed in my charge. Fig. 2 (Pl. II.) represents an unsymmetrical form which may be probably accounted for by the posterior position it has occupied in the jaw of the fish. The absence of lateral denticles dissociates them from *Carcharodon angustidens* and from *C. robustus;* they are distinguished by the thick prominent base of the latter, by the height of the crown in proportion to its breadth, and the concave curvature of the lateral margins which in the species now described are sigmoidal. They may further be distinguished from *C. angustidens* by their greater breadth in proportion to the height of the crown; it is thinner, the surface much less lustrous, and the marginal serrations less deeply indented.

Carcharodon megalodon, the largest of the Tertiary elasmobranchs, has an extremely wide geographical range. It has been found in the English, German, Swiss, Maltese, and Italian Tertiary strata. It is recorded from several American localities, and has been discovered in the Victorian Tertiary deposits near Geelong, in Australia. Its range is now extended by its discovery at Wekapass to New Zealand. Large teeth of this species, quite equal in size to any found fossil, were dredged by the *Challenger* expedition in the deep waters of the Atlantic and Pacific seas—a circumstance which indicates that this greatest of sharks existed until recent times in considerable numbers, and has become extinct within almost the historic period.

Formation and Locality.—Oamaru formation; Waireka series; Wekapass; Cape Foulwind; Nelson; near Cobley's Creek.

Ex coll.—Canterbury Museum, Christchurch; Geological Survey Collections, Wellington.

Carcharodon robustus, Davis.

(Pl. I., fig. 7.)

Teeth large, equilateral, erect, lateral denticles absent. Lateral margins finely serrated. The height is 2·1 inches from the central apex of the line dividing the crown from the base and the point of the tooth, and its breadth across the base is about 2·3 inches. The length of each lateral margin is 2·8 inches, making allowance for a small part of the base which is broken off. The external surface of the crown is almost flat, a slight convexity arising on each side the median line near the basal extremity. The internal surface is laterally convex, tapering towards the point. The line dividing the crown from the base is somewhat obtusely convex on the external surface, that on the opposite one being more acute, the two sides forming a right angle. The root is large and thick, open and porous in structure. It was probably 2·4 inches in breadth. Its surface recedes

from the front of the tooth, and extends in a well-rounded and prominent extension behind. The median portion is devoid of the prominent and well-defined projection of *Carcharodon angustidens*, Ag., and its lateral expansions are smaller and less prominent. On the other hand, the root of this species is deeper and more bulky in the median portion, thinning out towards each side. The under surface is moderately concave, whilst that of *C. angustidens* is deeply so. The crown of the two species may be readily distinguished by the difference in form; that of *C. angustidens* elongated, its lateral margins convex, with a lateral denticle on each side, and the external surface of the crown slightly convex; in this species the external surface is flat, the base is much wider and without denticles, and the lateral margins are decidedly concave.

Amongst European species to which this one appears to be most nearly related are the two species, *Carcharodon subauriculatus*, Agass., "Poissons Fossiles," vol. iii., p. 251, pl. xxx*a*., figs. 11–13, and *C. megalodon*, Agass., *op. cit.*, p. 247, pl. xxviii. The former may be distinguished by its greater breadth across the base of the crown and the more or less convex outline of the lateral margins. Its root is comparatively thin; and the tooth altogether less robust than the one now described. The same features which serve to discriminate this species from *C. subauriculatus*, viz. the thick and massive root, and the concave outline of the serrated edges, also distinguish it from *C. megalodon*. A doubt is expressed by Prof. Agassiz as to whether the two species, *C. megalodon* and *subauriculatus*, may not be the same. The former was described from specimens found in the Museum of Stuttgart, but the locality from which they were obtained was not known, others in the Museum at Paris were also without locality. It is not improbable that they may be varieties of one species along with, and including, that described by Agassiz as *Carcharodon rectidens*, "Rech. sur les Poissons Fossiles," vol iii., p. 250, pl. xxx*a*., fig. 10," in which case they would all be included in the species *C. megalodon*, Ag.

Formation and Locality.—Oamaru formation, Waitaki.
Ex coll.—A. M'Kay, Otago, New Zealand.

Genus. **Otodus.** Agassiz.

Agassiz, L. "Rech. sur les Poissons Fossiles," vol. iii., p. 266.

This genus is defined as occupying an intermediate position between Carcharodon and Oxyrhina or Lamna. It differs from Carcharodon in the complete absence of marginal serrations. It may be distinguished from Oxyrhina by the presence of a well-developed lateral denticle on each side the median cone. The lateral denticles are oftener rounded than compressed or sharp. The median cone is similar in form to the cone of Oxyrhina. In Lamna and Odontaspis the

lateral denticles or cones are smaller, more cylindrical and pointed, and the teeth generally more elongated: in Otodus they are broad. The root is largely developed and thick, but is devoid of the deep, lateral prolongations which distinguishes Lamna.

Otodus obliquus, Agassiz.

O. obliquus. Agassiz, L. "Rech. s. l. Poiss. Foss.," vol. iii., p. 267, Pls. xxxi. and xxxvi., figs. 22–27.

(Pl. vii., fig 16.)

A large tooth, well worn and rounded, apparently by attrition after fossilization, from the Amuri series of Amuri Bluff, appears to belong to this genus. The median cone is 0·8 inch across the base, and 0·7 inch in height. The upper part is much worn and very obtuse; the surface is smooth; on one side a small, rounded, lateral cone is preserved; the opposite one is broken away. The root is large and well rounded on the posterior surface; the margin of the under surface is concave; its lateral prolongations extending beyond the base of the crown. It is imperfect, and the exact dimensions cannot be given. It possesses many of the characters of *Otodus obliquus*, Agassiz, from the London clay, and is provisionally included in that species.

Formation.—Amuri series, Lower Greensand.

Locality.—West Wing, Amuri Bluff.

Ex coll.—Sir J. Hector, Colonial Museum, Wellington.

Genus. **Lamna.** Cuvier.

Agassiz, L. "Rech. sur les Poissons Fossiles," vol. iii., p. 287.

Teeth medium size; elongated; narrow in proportion to the height; sharply-pointed; cutting edge smooth; base expanded; lateral denticles present; root large, and deeply bifurcated.

The teeth of Lamna may be distinguished from those of Otodus by being rounder and less compressed, and having the lateral cones smaller and pointed. Oxyrhina is devoid of lateral denticles, and is thinner and more triangular in outline than Lamna. This genus first appears in the Chalk formation, and is still existing.

Lamna huttoni, Davis.

(Pl. iii., figs. 1 *a*, *b*, *c*.)

Teeth long, slender, curved, and pointed. The length of the crown 1·6 inches on the external surface. The base is 0·4 inch in diameter between the two

lateral margins; midway from the base to the apex the crown is 0·3 inch across, and thence it gradually tapers to the apex. The external surface is slightly convex near the base, much less so towards the apex; a groove runs along each margin, which, together with a similar one on the internal surface, causes the lateral margins to assume a sharp, cutting edge, which is continued towards and surrounds the point of the tooth. The internal surface is prominently convex from the base to the point. The basal portion of the crown is much expanded internally and externally, and there are indications of a somewhat massive root, but unfortunately this portion of the tooth is not perfect in any of the specimens. Secondary denticles, if they have been present, are not preserved. The line dividing the enamelled surface from the root is higher on the internal than on the external surface. The tooth is curved sigmoidally. (Pl. III., fig. 1*c*.) A series of minute striæ extend vertically from the base towards the point on the internal surface; the striæ disappear before reaching the lateral margins, leaving along each a smooth space. The external surface is entirely smooth. Examples of the teeth exhibit a peculiar twist or contortion of the crown, not shared by the majority, which is probably due to the position which the tooth occupied in the mouth.

This species appears to be somewhat nearly related to *Lamna elegans*, Agass. ("Poiss. Fossiles," vol. iii., p. 289, pl. XXXV., figs. 1–7, and pl. XXXVII *a*, figs. 58, 59), from the London clay, and the Calcaire grossier near Paris. *L. elegans* is slender, regular, and erect, having a considerable thickness near the root, and tapering towards the point; it possesses a small lateral denticle on each side the median cone, and its margins are sharp; this species may be distinguished from *Lamna elegans* by its elongated and less triangular form, greater curvature, and its slightly contorted or twisted outline.

A number of specimens of this species occur in the Curiosity Shop beds horizon at Gorge Hill, Pareora. They are the lowest beds of the Oamaru formation. The teeth are preserved in a peculiar manner. The outside enamelled shell of the tooth remains intact, whilst the whole of the interior structure is gone, leaving simply a hollow cube. They are very fragile.

I have taken the liberty to designate this species by the name of Prof. F. W. Hutton, to whose initiative I am indebted for the opportunity to arrange and describe the fossils here enumerated.

Formation.—Oamaru system and Waireka series.

Localities.—Marnawhenna; Otago; Awamoko; Amuri Bluff; Cave Valley, Oamaru; Gorge Hill, Pareora.

Ex coll.—Messrs. J. D. Enys, B. Gillies, and Ashcroft; Canterbury Museum. Geological Survey Collections, Wellington.

Lamna incurva, Davis.

(Pl. III., figs. 2–5.)

The teeth of this species differ from those of *Lamna huttoni* in their greater acuteness, rounded form, and the almost total absence of lateral cutting edges. The average length is 0·8 inch, the base of the crown 0·2 inch across, whence it gradually decreases to the point. The external surface is slightly convex throughout its length; it is perfectly smooth. The internal surface is deeply convex and also smooth: in this respect differing from *L. huttoni*, which is striated on the internal surface. The diameter of the tooth between the external and internal surfaces is little less than the lateral one, in this respect also differing from *L. huttoni*, in which the relative diameters are as two to one. The teeth are curved considerably inwards from the base of the crown nearly to the apex, the latter having a slight inclination forwards. Lateral denticles absent. Base of the crown straight across the external surface; on the internal one it is arched upwards to a considerable extent.

The roots in the specimens now described from Coleridge Gully and Curiosity Shop are very imperfectly preserved. A specimen collected by H. A. Ingles, Esq., from the Amuri Limestone of the Kaikoura Peninsula, exhibits the root in a good state of preservation. It retreats from the external surface of the crown, leaving a deep concavity; two prongs descend from the lateral extremities to a considerable depth. The internal projection is large and prominent, forming a somewhat angular bulb, from which the surface retreats on each side to the lateral prongs (Pl. III., fig. 2 *a*).

A small specimen is represented on Pl. III., fig. 5. Compared with the others it is short and thick.

The teeth occupying the anterior position in the jaws are broader, slightly larger, and much less curved than those situated posteriorly; they are elliptical in section, as compared with the others, which are nearly circular. A large number of specimens of this species have been found. They vary much in size; the largest, a posterior tooth from the Curiosity Shop beds, is 1·1 inch in length. It is partially embedded in a matrix of brownish, shelly limestone. Others are less than one-third that size. The smaller ones, however, possess all the characters identifying the larger, and there can be little doubt that they are young examples of the same species.

Several small specimens of this species have been found in the beds at Gorge Hill, Pareora. They are preserved in a similar manner to *L. huttoni*, already described, from the same locality.

Formation.—Oamaru and Waipara systems; Waireka series; Cretaceo-Tertiaries.

Localities.—Broken River; Curiosity Shop; Coleridge Gully; Amuri Limestone; Kaikoura Peninsula; Gorge Hill, Pareora; Waitako Valley; Tata Island

Limestone, Nelson; Trelissic, Canterbury; Mercer, Waikato River, Auckland; White Rock, Malvern Hills; Waihola series, Otago.

Ex coll.—Canterbury and Otago Museums; Geological Survey Collections, Wellington. H. J. Ingles, Esq.

Lamna ensiculata, DAVIS.

(Pl. III., figs. 6, 7.)

A few examples of this species have been found in the Oamaru formation or Lower Miocene of Prof. Hutton, at Oamaru. The tooth most perfectly preserved and selected as the type is 0·65 inch in height; the margins are equilateral, 0·8 inch in length; the base of the crown bifurcates laterally into two forks, the extremities of which are 0·5 inch across; the crown is 0·2 inch across the external face, converging towards the apex, and ending in an obtuse point. The tooth is strong, erect, the slightly convex inclination of the external aspect being balanced by that of the internal surface. The external surface is moderately convex, its lateral margins forming a nearly rectangular junction with those of the deeply convex internal surface. At a distance of 0·5 inch from the apex the crown suddenly expands laterally and bifurcates, the commencement of the expansion being marked by a peculiar constriction of the surface. The bifurcation extends over the lateral forks of the root. The root is more widely expanded than the base of the crown, and descends in lateral prongs, with a wide and highly concave space between. The central portion of the root forms internally a prominent bulb, whilst the external base of the crown is free; the lateral prongs extend outwards from the internal median prominence with a bold curve, ending more or less acutely. They are thick and strong. A faint indication of lateral denticles exists on each side of the base of the crown.

This species is readily distinguished from any others from the New Zealand strata by the, at first constricted, and then widely-expanded base, and the straight, thick, obtusely-pointed crown. In the latter respect *Lamna huttoni*, approaches nearest, but its striated internal surface and curved aspect distinguish it. Amongst European species *Lamna cuspidata*, Agassiz ("Poissons Fossiles," vol. iii., p. 290, pl. XXXVII. *a*, figs. 43–50), from the Tertiary beds of Switzerland, is probably most nearly related. It is similarly erect, smooth on each surface, and thick. Its root is large and widely bifurcated. The characters of the base of the crown, given above, and the absence of well-defined lateral denticles, which are conspicuous in well-preserved specimens of *L. cuspidata*, Ag., separate this species from the Swiss one.

Formation.—Oamaru formation.

Locality.—Oamaru.

Ex coll.—Canterbury Museum, Christchurch, New Zealand.

Lamna marginalis, Davis.

(Pl. iii., figs. 8–10.)

The specimens comprised in this species are in some respects much like examples of the genus Oxyrhina. The crown is thin and flat, wide at the base, diminishing to a point. The presence of a small lateral denticle, however, indicates most clearly its relationship with the genus Lamna. The height of the crown is 0·6 inch, width across the base of the median cone 0·3 inch, to which must be added 0·05 inch on each side, to include the lateral denticle. The external surface is flat or slightly convex and smooth, rising in a straight line from the base to the apex. The internal surface is convex; from the base of the enamel a number of minute striæ ascend the crown to a distance of one-third its height, gradually disappearing. The margins are very thin and knife-like. The line dividing the crown from the root on the external surface is straight; on the internal surface a little concave. The lateral denticles are small, rather rounded than pointed. The root is large and widely expanded, retreating from the median external surface with a moderate concavity and a corresponding convexity on the internal one; the root descends on each side diagonally, the terminations being separated by a distance of 0·7 inch—double the width of the base of the crown. The prongs are thin and aliform; the median teeth are straight, with equilateral margins, the internal surface presents greater convexity, and consequently they are thicker than the teeth derived from the posterior parts of the jaws. The latter are more or less arched backwards.

This species is easily recognised amongst other New Zealand forms by its thinness, especially at the lateral margins, hence its specific name, by the obtuse lateral denticles and the great lateral expansion of its root.

Formation.—Oamaru and Waipara formations; Cretaceo-Tertiary.

Localities.—Broken River; Amuri Limestone; Kaikoura Peninsula; Totora Limestone, Mokau Valley; Nummulite Beds, Wharaema; Calcareous Greensand, Wekapass; Teredo Limestone, East Wing, Amuri Bluff.

Ex coll.—Otago Museum; Canterbury Museum, Christchurch; Geological Survey Collections, Wellington.

Lamna attenuata, Davis.

(Pl. iii., fig. 11.)

Small teeth, 0·25 inch in length, 0·1 inch across the base; base rapidly becomes accuminate, and the central cone ascends in a fine shaft, with a finely pointed apex. External surface rounded and curved inwards. Internal surface still more convex,

expanding at the base with a concave outline dividing it from the root; lateral margins scarcely perceptible. A minute lateral denticle arises on each margin. The root is absent. This small tooth is characterized by the extreme tenuity of its form and the roundness of the cone.

Formation.—Oamaru formation.

Locality.—Coleridge Gully.

Ex coll.—Canterbury Museum, Christchurch, New Zealand.

Lamna lanceolata, Davis.

(Pl. iii., figs. 12 *a*, *b*, *c*, *d*.)

The teeth of this species have been obtained from several localities of the Oamaru formation. They are of peculiar lanceolate form, erect, slender, and generally well worn and rounded at the apex. The teeth are firmly attached to a large and clavate root. The crown is 0·6 inch in length, and to this must be added 0·25 inch, the depth of the root. Except in rare instances the root is detached, fortunately one or two specimens are perfect. A number of the specimens are curved backwards, due probably to their occupation of a position on the posterior part of the jaws. The external surface is slightly convex near the base; higher it is plane in the centre, slightly depressed on each side towards the margins, which are thin but rounded. The width of the tooth is 0·15 inch, gradually tapering near the apex. The internal surface of the crown is very slightly more convex near the base; its upper part is depressed in a similar manner to that of the external surface. The base of the crown is expanded, and contrary to the ordinary rule in this genus the outline is more or less convex on each side. The surface of the crown is quite smooth. The posteriorly curved teeth are somewhat more slender than the erect anterior ones, and the lateral margins begin to converge towards the apex, at a point nearer the base. The root is very large and thick; from the base of the crown it expands rapidly, especially in the posterior direction; its inferior antero-posterior diameter attains 0·45 inch, laterally it is 0·25 inch. In form it resembles a clubfoot twisted backwards. Its under surface is hollow (fig. 12 *d*).

This species is included in the genus Lamna with some little doubt. The long, thin, slender crown, and the thick, solid, nonbifurcating root do not conform with the characters of the genus, except in a superficial manner; there are no lateral denticles; in the latter respect it agrees with Oxyrhina, but it cannot be considered as a species of that genus.

Formation—Oamaru formation.

Localities.—Castle Hill Station, Canterbury; Broken River, Coleridge Gully.

Ex coll.—John Davies Enys, Esq., Cambridge Museum, Christchurch.

Lamna carinata, Davis.

(Pl. iii., fig. 13.)

This species is closely allied to the last described (*L. lanceolata*, Davis); it differs in being curved inwards, instead of straight towards the point; it is thicker, with angular lateral margins, and a median carina along the external surface. From the latter feature the species derives its specific appellation. The tooth is 0·5 inch in length; the root is not preserved. The external surface is 0·1 inch in breadth; it is plain, excepting a keel, which runs up the centre from the base to the apex; the lateral margins are slightly produced and form an angular and sharp edge. The internal surface is convex, and vertical striæ extend from the base nearly to the apex. The tooth bends gently inwards. The line dividing the crown from the root appears to have been straight. The root is absent.

Formation.—Waipara formation.

Locality.—Amuri Limestone; Kaikoura Peninsula, Kaikoura, New Zealand.

Ex coll.—H. J. Ingles, Esq., Otago Museum.

Lamna sp. (?) *Vertebræ.*

(Pl. iii., figs. 14, 15.)

Several vertebræ have been discovered in the strata of the Oamaru formation. They vary in size, and may not all belong to the same species of shark. The specimen represented on Pl. iii., fig. 14, is the vertebra of a Lamna. It is deeply biconcave; the periphery is constituted of a number of columns separated by large interspaces, which have afforded space for the insertion of the cartilages supporting the apophysis. The external diameter of the centrum is 1·3 inch, and the height of the periphery 0·6 inch.

A second specimen represented by fig. 15 is much smaller. It is similarly biconcave, but the divisions of the periphery are less numerous, and it has a more dense and stronger appearance than the larger specimen.

Formation and locality.—Oamaru formation. (14) Awamoke. (15) Kaikoura.

Ex coll.—(14) R. Gillies, Esq. (Prof. Hutton). (15) T. J. Parker, Esq., Otago Museum.

Lamna hectori, Davis.

(Pl. iii., fig. 16.)

Teeth medium size, robust, equilateral, expanded near the base, with a minute denticle on each side. External surface only visible, the internal one embedded

in the matrix. Median length of the crown 0·4 inch; on each side, to the extremity of the root, it is 0·6 inch; breadth across the base 0·3 inch, higher the base is speedily reduced to one-half that diameter, and thus diminishes to a somewhat obtuse point. The external surface of the crown is depressed, with the exception of a broad median ridge, extending from the base half-way up the tooth. The margins are slightly produced, but not acutely, as in *Lamna marginalis*, Davis. Near the base they become somewhat bulbous and expanded, and an indentation separates the base of the margin from a small lateral denticle on each side. The surface is smooth, without striations. The root is short, width the same as the base of the tooth. The lateral portions extend one-tenth of an inch; the median area is depressed deeply, lobate and concave. The internal surface is hidden in the matrix. It is proposed to distinguish this species by the name of its discoverer, Sir James Hector.

Formation.—Amuri series.

Locality.—West Wing, Amuri Bluff.

Ex coll.—Sir J. Hector, Geological Survey of New Zealand.

Genus. **Odontaspis.** M. & H.

Odontaspis. MULLER and HENLE. "Systematische Beschreibung der Plagiostomen," p. 73.

Teeth medium size, long, tapering, acuminate, cutting edges smooth, base widely expanded, lateral cones variable in number, larger, and sharper-pointed than those of Lamna.

Odontaspis is regarded by MM. Müller and Henle as a distinct and well-defined genus, and Dr. Günther regards it from a similar point of view. Prof. Agassiz ("Poiss. Foss.," vol. iii., p. 287) was of opinion that its characteristics are not of sufficient importance to necessitate a separate genus, and he describes a number of species of the type of Odontaspis as a sub-genus or variety of Lamna. The remains of the genus Odontaspis first appear like that of Lamna in the chalk formation, and the genus attained its greatest abundance during the Tertiary period. It still survives in the seas of the present day.

Odontaspis acuta, DAVIS.

(Pl. v., figs. 1, 2.)

The teeth on which this species is based are amongst the most rare forms derived from the Oamaru formation, they are found in the Curiosity Shop beds and at Trelissic, Canterbury. The teeth are of moderate size, slightly curved

outwards, graceful in outline, sharply-pointed, broad at the base, arising from which, in addition to the large central cone, are two or three small lateral denticles on each side, diminishing in size as they recede from the centre. The external surface of the median cone is depressed at the base, the latter having a slightly concave margin where attached to the root. The higher surface of the cone is convex, and towards the point slightly recurved; the median height is 0·7 inch. The first small denticles rise from the base to a height of 0·1 inch; they are sharply-pointed and curve inwards towards the central cone. Beyond these the second and third denticles are similar in form, but less in size. The base of the crown is 0·5 inch in breadth. The internal surface is only partially exposed, the basal portion of the tooth lies hidden in matrix; the upper part is convex, slightly more so than that of the external surface. The lateral margins are produced, and moderately thin and sharp, a character shared by those of the lateral denticles. The root is deeply concave on the anterior surface and correspondingly prominent behind; it extends laterally to a considerably greater width than the base of the crown. (See fig. 2 *a.*)

This species differs from others from the strata of New Zealand, in the peculiar form and arrangement of the denticles. Other species of the same genus occur, but they are easily distinguished by the shortness of the median cone in proportion to the breadth of the base. Of European species they most nearly resemble *Odontaspis acutissima*, Agassiz. ("Poissons Fossiles," vol. iii., p. 294, pl. XXXVII*a.*, figs. 33, 34.) It is described as very sharp, with one long lateral denticle, equally sharp on each side; the internal face is striated. The locality from which the type was obtained is not known, but a second specimen was found in the Tertiary strata of Berthond, in Switzerland. This species differs in the length, and less acuminate form of the central cone, and in the presence of three lateral cones instead of one. The latter feature also distinguishes this species from that of *O. subulata*, (*op. cit.*, p. 296, pl. XXXVII *a.*, figs. 5, 7), from the chalk and greensand, which closely resembles *O. acutissima*, Agassiz, in its form.

Formation.—Oamaru system.

Locality.—Curiosity Shop beds, and Trelissic, Canterbury.

Ex coll.—Canterbury Museum, Christchurch, New Zealand; Geological Survey Collections, Wellington.

Odontaspis exigua, Davis.

(Pl. v., figs. 3, 4, 5.)

Teeth small, middle cusp acutely angular and inclined posteriorly, with two smaller cusps on each side, the outer ones smallest. The outer surface nearly flat at the base, slightly convex above; inner surface strongly convex; cutting edges fine and smooth, points acuminate. Ganoine of surface strong and glistening,

smooth on the outer surface, with slight striations on the inner; most clearly marked near the base. Line dividing crown from root straight on both sides. Root more widely expanded than the base of crown, convex on the outside, deeply concave on the inner one, with lateral extremities boldly prominent, and more or less pointed. Height of median cone 0·3, breadth of base 0·35 inch, of which the median cone occupies 0·2 inch. Root 0·1 inch in depth, greatest width 0·4 inch. This tooth (fig. 3) probably occupied a position midway between the anterior and posterior extremities of the jaw. Others occur of similar form but smaller, and others again, which appear to have belonged to the same species (fig. 5) are more elongated in proportion to the breadth, finely pointed and possessing only one denticle on each side the principal cone. The latter were probably located in the front of the jaw. The small tooth (fig. 4) has the characteristics of one of the small posterior teeth almost equally divided into three cones, the two lateral ones being quite half the size of the median one in this specimen. The tooth is 0·15 inch in breadth, and the height, including the root, is about the same.

This species differs from *O. acuta* in having a broadly expanded base, the cones being more triangular and flatter, those of *O. acuta* are recurved more or less sigmoidally, whilst in this species they are straight.

Formation.—Oamaru formation.

Locality.—Broken River. Castle Hill Station, near Canterbury; Coleridge, Trelissic.

Ex coll.—J. D. Enys, Esq., Canterbury Museum, Christchurch; Geological Survey Collections, Wellington.

Odontaspis kaikoraensis, Davis.

(Pl. v., figs. 6–10.)

Teeth very broad, with thick base, from which ascends a median cone; and on each side, separated by a wide interval, is at least one lateral denticle. The base of the tooth is 0·5 inch across; and the height of the median cone, including the base, is 0·55 inch; of this the base takes 0·2 inch. Median cone is erect, tapering, slightly curved outwards; lateral margins produced and sharp; internal surface convex, extern alone flat; the surface is enamelled and smooth, the apex pointed; the lateral denticles are broad at the base, short, obtusely pointed, separated by their own diameter from the central cone; the base is externally concave, prominent on each side; the internal surface is produced below the median cone, retreating on each side; the inferior surface is concave.

This species differs from any other previously described from New Zealand in the great width of the base, as compared with the diameter of the denticles and in

the open space between the central cone and the lateral cones. The central cone is slender and somewhat cylindrical—a feature which appears to indicate its generic relationship with either Lamna or Odontaspis, whilst distinguishing it from Otodus, the median cone of which is broad and compressed. The imperfection of one of the lateral extremities renders the number of lateral denticles uncertain; and the distinction made by Prof. Agassiz ("Poiss. Foss.," vol. iii., p. 287) between Lamna, with not more than one denticle on each side, and Odontaspis, with a variable number, cannot be readily made out; but other specimens from the same locality, though not so perfect in other respects, have two lateral denticles on one side the median cone, if not on both.

Formation and Locality.—Waipara system; Kaikoura; Amuri Bluff.

Ex coll.—Sir Julius von Haast; J. Davies Enys, Esq.; Geological Survey Collection, Wellington.

Odontaspis sulcata, DAVIS.

(Pl. v., figs. 11, 12, 13.)

Teeth, with large base, 0·5 to 0·8 of an inch in extent; the central cone rises to a height slighly less than half the breadth of the base; in a tooth 0·6 across the base, the height of the cone is 0·25 inch, and its width 0·15 inch; on each side the median cone are two or three lateral cones, diminishing in size as they recede from the centre. All the cones are deeply grooved at the base; the grooves disappear midway up the surface. The upper part is smooth; the lateral margins are smooth, and, where unworn, form a sharp cutting-edge. The base is 0·1 inch in depth, anteriorly concave and somewhat retreating, posteriorly more or less produced.

This species may be distinguished from those already described by the large expansion of the base, and the proportionate width of the lateral cones. The deeply-sulcated character of the lower portion of the several cones is not found in other species from New Zealand.

Formation.—Black Grit series.

Locality.—East Wing, Amuri Bluff.

Ex coll.—Sir J. Hector, Colonial Museum, Wellington.

Genus. **Oxyrhina.** Agassiz.

Oxyrhina. Agassiz, L. "Rech. sur les Poissons Fossiles." vol. iii., p. 276.

Teeth medium size, acutely triangular, compressed, slender, margins smooth, acute point, without lateral denticles or cusps.

Prof. Agasssiz regarded Oxyrhina as closely related to the genus Lamna, but distinguished by its slender and flat or compressed form, the true Lamna being thicker, straighter, and not so broad. It is also devoid of lateral denticles, which Lamna possesses. The genus Otodus is broader, less compressed, and more triangular in outline. It is also possessed of lateral denticles.

The genus Oxyrhina is found in the chalk, but is most abundant in the Tertiary formations.

Oxyrhina von haastii, Davis.

(Pl. iv., figs. 1–3.)

This species occurs in considerable numbers in the Lower Limestone at Oamaru. The teeth average an inch in length, broad at the base, they gradually taper to an acutely-pointed apex. The lateral margins are devoid of serrations, and form a sharp cutting-edge. The external surface is more or less flat, slightly concave near the base. The enamel is grooved at the base, the slight channels so formed disappearing on the surface towards the apex. The point is curved outwards. The internal surface is deeply convex, expanding widely at the base to envelop a largely expanded root, and bending sigmoidally upwards towards the recurved apex. The base of the enamel forms a slight concavity on the external surface, the concave outline being considerably emphasized on the internal one.

A mass of limestone with about twenty teeth attached is included in the collection brought by Sir Julius von Haast from the Canterbury Museum. The teeth have evidently belonged to one fish; but they are much confused, and do not afford evidence of the actual position of the teeth in the mouth. They are all thickly coated with a creamy white enamel. Some of the teeth are erect, the lateral margins forming an equal angle with the base; others present a considerable obliquity, as represented in fig. 2. The erect examples, which probably occupied an anterior position, near the symphysis of the rami of the jaws, with a height of one inch, are 0·7 inch across the base of the crown. The oblique teeth, from the posterior portion of the jaws, having the same length, attain one inch across the base; the posterior margin, one inch in length, concave in outline, and the anterior one, convex, is 1·3 inch in length.

The root is large, prominent on the internal surface, and descending laterally

on each side to a depth, from the median bulb of the root, equal to the height of the crown. The lateral projections of the root are strong and rounded, with a deep concavity between them.

This species possesses characters readily distinguishing it from others previously described. Several characters of all the species of this genus exist in common, such as the equilateral, elongated teeth occupying the front of the mouth, and the more or less obliquely-arched teeth of the back. In this species the sigmoidal curvature of the antero-posterior aspect of the tooth, and the great length of the lateral prongs of the root distinguish it. It probably approaches more nearly to *Oxyrhina hastalis*, Agass. ("Poiss. Foss.," vol. iii., pl. xxxiv., figs. 1–17, p. 277), than to any other. From this it differs in the following particulars:—*O. hastalis* is comparatively thin; the prongs of the root are short, the posterior teeth much less obliquely arched, the base of the enamel on the internal surface of the crown forms a straighter line, and there is a median ridge extending from the base three-fourths the height of the tooth on the external surface of the crown. The anterior teeth of the species now described bear a superficial resemblance to some of the teeth of *Oxyrhina mantellii*, Agass. (*op. cit.*, p. 280, pl. xxxiii., figs. 1–9); but they are readily distinguished by the greater breadth of the posterior teeth in proportion to the height of the crown. The deep concavity of the posterior margin of the arched teeth, and the shortness of the root of *O. mantillii*, as compared with *Oxyrhina von haastii*, also indicate important differences.

A number of the teeth of Oxyrhina have been found by the Rev. J. E. Woods associated with characteristic chalk fossils at Mount Gambier. They vary from less than an inch to three or four inches in length, and have been named, but not described, by Prof. F. M'Coy, "*Oxyrhinus woodsii.*." A woodcut is given of the teeth in "Geological Observations in South Australia," 1862, by the Rev. J. E. Woods, which appears to indicate a somewhat close resemblance to *O. hastalis*, Ag. (see fig. 8, *op. cit.*), and shows them to be sufficiently distinct from the species now described.

Formation.—Oamaru formation.

Locality.—Oamaru.

Ex coll.—Cambridge Museum, Christchurch; Geological Survey Collections, Wellington.

Oxyrhina recta, Davis.

(Pl. v., fig. 14.)

The teeth of this species are of medium size, regular in outline, comparatively thin, without outward flexure of the crown, and the root extends downwards with widely-distended lateral prongs. The median height of the crown is 0·9 inch, the

length of the lateral margin 1·15 inch, and the width across the base about 0·5 inch. The roots are extended to a width of 1·2 inch between their extremities. The length of the root is equal to the height of the crown, each measured from the middle of the base of the external surface of the crown. The external surface is convex, only slightly less so than that of the internal aspect. Both ascend without perceptible curvature from the base, and converge at the apex. The lateral margins are thin and sharp, each with a slightly sigmoidal curvature; the enamel of the crown descends on each side, so as to envelop a considerable portion of the lateral margin of the root. The base of the enamel on the external surface is slightly concave, that of the internal surface is more deeply rounded. The root is large, well-rounded on the internal surface, and descending on each side to a considerable length, and terminating in a pointed prong. The root retreats on the external surface, and is concave. The inferior surface between the prongs is deeply concave.

This species is probably most nearly related to *Oxyrhina von haastii*, Davis, especially in the extension of the prongs of the roots; the two may be distinguished by the more divergent arrangement of the prongs in this species, and the prolongation of the enamel over the lateral surfaces of the root. The crown of *O. v. haastii* is curved externally; in this one it is straight. The crown of the latter is moderately convex on each surface, that of *O. v. haastii* is externally flat, and internally very much more convex. This tooth is considerably thinner than *O. v. haastii.* It also superficially resembles the anterior teeth of *Oxyrhina enysii*, Davis, it differs in the convexity of the external surface, and its rectitude from the base to the point without external flexure.

Formation and Locality.—Oamaru system ; Castle Hill Station, Canterbury.

Ex coll.—John Davies Enys, Esq.

Oxyrhina enysii, Davis.

(Pl. v., figs. 17–20.)

A large number of teeth of small and medium size have been obtained from the Oamaru formation at Broken River, they are mostly oblique, occasionally erect, lanceolate, acutely pointed, lateral margins smooth. The external surface of the crown is almost flat, with a slight median depression near the base, the point curved gently outwards. The internal surface is convex. The base of the crown expands on both the external and internal aspects of the tooth, especially the latter, where it has been attached to the cartilaginous jaw, apparently without the intervention of an osseous root, there being no evidence on any of the specimens of the existence of the latter. The enamelled surface extends in a line almost straight across the external surface; that on the internal one is more or less

concave. The teeth exhibit considerable variation in form and size, the largest are 0·9 inch in length, those obliquely curved are widest at the base, the width equalling two-thirds of the height; they were probably situated on the posterior part of the jaws. The straighter anterior teeth are little more than half the width of their height.

Teeth of the same genus, and apparently of the same species, have also been found in the Waipara formation. They exhibit a greater amount of obliquity, but otherwise do not materially differ from those of the Oamaru rocks.

I have pleasure in suggesting the specific appellation *Oxyrhina enysii*, in recognition of the services rendered to palæontological science by Mr. J. D. Enys.

Formation and Locality.—Oamaru formation; Broken River and Waipara formation, Waipara.

Ex coll.—J. D. Enys, Esq., Otago Museum; Canterbury Museum, Christchurch.

Oxyrhina acuminata, Davis.

(Pl. v., fig. 21.)

The beautiful example which forms the basis of my description of this species was collected and forwarded to me by John Davies Enys, Esq., of Canterbury. The tooth is lanceolate, slightly arched backwards, the point curved outwards; its median length from the base of the crown to the apex is 1·9 inch; the length of the anterior lateral margin 2·2 inches, and that of the posterior margin 2·0 inches, the latter slightly concave, the former convex. The width of the base of the crown is 1·2 inch; for the root must be added half an inch to the length and its greatest width is 1·3 inch. The lateral margins of the tooth are smooth and sharp, converging and forming an acutely-pointed apex. The external surface is slightly hollowed, especially the upper part; towards the base the hollow descends on each side, and the median portion is a little raised. The internal aspect of the tooth is gently convex; the base of the enamel forms a well-pronounced curve, much more so than that of the external surface. The root is concave externally, and gently convex on the opposite surface; the lateral extensions are not very pronounced, extending downwards somewhat less from the base of the crown than the median portion; the inferior surface conforms roughly to the concave margin of the base of the crown on the external surface.

This species differs from *Oxyrhina von haastii* by the small dimensions of its root, by its lanceolate outline, the highly-curved point, and more especially in the smaller breadth between the external and internal surfaces, due to the comparatively small convexity of the internal surface of this species as compared with *O. von haastii.*

The elongated teeth of *Oxyrhina xiphodon*, Agass. ("Poiss. Foss.," vol. iii., p. 278, pl. xxxiii., fig. 12), resembles this one in general outline, but may be distinguished

by the median depression of the internal surface of the crown, and in the base of the enamel being equally curved on both the external and the internal surface.

Formation.—Oamaru formation.

Locality.—Castle Hill Station, near Canterbury, New Zealand.

Ex coll.—John Davies Enys, Esq.

Oxyrhina grandis, Davis.

(Pl. v., figs. 15, 16.)

Teeth much elongated, thick and strong, point curved outwards; length of crown 1·8 inch, breadth at base 0·7 inch. The external surface slightly but uniformly convex from the base to the apex. The internal surface deeply convex, expanding towards the base, and curving near the apex over towards the external aspect. The lateral margins more or less equidistant and produced so as to form a sharp cutting-edge. Root not sufficiently well preserved to afford reliable indications of its form. Other specimens from the same beds, probably of the same species as those described, are somewhat shorter in proportion to the length, and are arched in an oblique direction backwards, the latter have probably been derived from the posterior part of the mouth, and the longer teeth from the anterior. The characteristics of this species which distinguish it from others are, the great length in proportion to the width, and the semi-rotundity of its horizontal section, produced by the double convexity of both the internal and external aspects. Whilst *Oxyrhina acuminata* may be distinguished by its thinness in proportion to its length and breadth, this species may be equally well recognised by its thickness or rotundity, as compared with the length and breadth of the tooth.

Formation.—Oamaru and Waipara systems; Cretaceo-Tertiary.

Localities.—Broken River; Curiosity Shop; Wekapass; Greensand conglomerate, South Wing, Amuri Bluff; Amuri Limestone, Amuri Bluff.

Ex coll.—Canterbury Museum, Christchurch; Geological Survey Collections, Wellington.

Oxyrhina fastigata, Davis.

(Pl. vi., figs. 1–3.)

A large number of small teeth, not more than half an inch in length, and about half that in breadth across the base, occur in the Oamaru formation, principally in Coleridge Gully. The form varies according to the position which

the teeth have occupied in the mouth, a proportion being erect with equilateral margins, others arched more or less obliquely backwards. The external surface is convex, but to a smaller extent than the internal one. The base of the crown extends in an almost straight line across the tooth on the external surface, with a slightly upward tendency on the internal one. The base of the crown on the latter surface is produced outwards, whilst that of the external surface is correspondingly depressed, and forming a hollow which ascends a short distance on the enamelled crown. The crown is enveloped in enamel, smooth and unstriated. The root is moderately large, extending backwards, and forming a well-rounded bulbous prominence on the internal surface; a correspondingly deep concavity exists on the external face. The concavity of each succeeding tooth fitting to the bulbous prominence of the one before it.

The teeth now described are separated from those of *Oxyrhina enysii*, Davis, by their elongated form, and the narrowness of their base in proportion to their height. The obliquely-curved posterior teeth of *O. enysii* are, in some of the teeth exhibiting greatest curvature, and probably derived from the most posterior part of the jaw, as broad across the base as the length of the concave, or shorter lateral margin, a feature which immediately distinguishes them from this species. The external surface of the latter is convex, whilst that of *O. enysii* is flat, or nearly so.

Formation.—Oamaru formation.

Locality.—Coleridge Gully.

Ex coll.—Canterbury Museum, Christchurch.

Oxyrhina subvexa, Davis.

(Pl. vi., fig. 4.)

The type of this species is a single specimen from Hog's Back, New Zealand, collected and sent by Mr. J. Davies Enys. Its nearest relationship appears to be with *Oxyrhina von haastii*, Davis; it is, however, so dissimilar from the teeth of that species that it is undesirable to place it with them, and it is therefore treated as a separate species. The discovery of additional specimens may prove the correctness, or otherwise, of this determination. The tooth was probably situated on the posterior part of the jaw; it is arched, with a slight obliquity backwards; the height along the median line is 1·1 inch; the posterior margin 1·0 inch, and the anterior one 1·2 inch; the base of the crown is 0·7 inch across. The external surface presents a somewhat undulating appearance. Midway between the base and point the central part of the tooth is concave, from the centre it rises on each side, as well as towards the point and the base, and forms a slight convexity.

The base of the crown is plicated, the folds extending about 0·2 of an inch upwards. A groove also extends from the base to the point along each lateral margin, rendering the margins thin, almost transparent. The internal surface is moderately convex; towards the base it becomes greatly expanded, indicating a large root; the latter is, however, unfortunately absent. The anterior lateral margin is convex, except towards the base, where it turns outwards over the root. The posterior margin is concave for one-third its length from the point, deeply so for a similar distance from the base, the intermediate third being convex. The external base of the crown is straighter, and descends lower, than that of the internal surface.

Formation.—Oamaru system.
Locality.—Hog's Back.
Ex coll.—John Davies Enys, Esq., Canterbury, New Zealand.

Oxyrhina lata, Davis.

(Pl. vi., fig. 5.)

Teeth pyramidal in outline, equilateral. Crown 0·5 inch in height, 0·4 inch across the base. External surface slightly convex, with minute sulci at the base; lateral margins straight, smooth; apex acutely-pointed. Internal surface for the most part hidden in the matrix; upper part exposed, convex. Root large and strong, broader than the base of the crown. Line dividing the crown from the base on the external surface straight.

Oxyrhina lata is distinguished from all the New Zealand species by the great breadth of the base of the crown as compared with its height, and the straight lateral margins. These peculiarities serve also to separate this species from others previously described. *Oxyrhina triyonodon*, Agassiz ("Poissons Fossiles," vol. iii., p. 279, pl. xxxvii., figs. 17, 18), from the Tertiary strata of the valley of the Rhine, is characterized by its very regular form representing an isosceles triangle, and the thinness of the tooth. The base of the tooth in the species now described represents a tooth of considerable thickness, and the uniform, though slight, convexity of the external surface differs from that of *O. trigonodon*, which has a groove running parallel with the margin on each side. The latter is a large tooth two or three inches in length, which further separates it from this species, which is a small tooth.

Formation—Oamaru system.
Locality.—Kakahu River, South Canterbury, New Zealand.
Ex. coll.—Prof. F. W. Hutton, Otago Museum, New Zealand.

Family. **NOTIDANIDÆ.**

Genus. **Notidanus.** Cuvier.

Dentition unequal in the jaws; in the upper jaw one or two pairs of awl-shaped teeth, the following six being broader and provided with several cusps, one of which is much the strongest. Lower jaw with six large comb-like teeth on each side, besides the smaller posterior teeth. Spiracles small, on the side of the neck. No pit at the root of the caudal fin. Gill openings wide; six in number in Hexanchus, seven in Heptanchus. One dorsal fin only, without spine, opposite to the anal (Günther).

Notidanus primigenius, Agass.

(Pl. vi., fig. 6.)

Notidanus	primigenius,	L. Agassiz, 1843, .	"Poiss. Foss.," vol. iii., p. 218, pl. xxvii., figs. 4–8, 13–17.
,,	recurvus, .	,, 1843, .	*Op. cit.*, p. 220, pl. xxvii., figs. 9–12.
,,	primigenius.	R. W. Gibbes, 1849,	"Journ. Acad. Nat. Sci., Philad.," ser. 2, vol. i., p. 195, pl. xxv., fig. 95.
,,	,,	A. Quenstedt, 1852, .	"Handb. Petrefakt.," p. 167, pl. xiii., fig. 3.
,,	,,	J. Probst, 1858, .	"Wurttb. Jahreshefte," vol. xiv., pp. 124–127.
,,	,,	R. Lawley, 1877, .	"Atti Soc. Toscana Sci. Nat.," pp. 66–68, pl. i., figs. 1–5.
,,	recurvus, .	,, 1877, .	*Op. cit.*, pp. 69, 70, pl. ii., fig. 1.
,,	,,	J. Probst, 1879, .	"Wurttb. Jahresh.," vol. xxxv., pp. 162, 163, pl. iii., figs. 12–17.
,,	primigenius,	,, 1879, .	*Op. cit.*, pp. 158–162, pl. iii., figs. 1–5.
,,	,,	F. Noetling, 1885, .	"Abh. Geog. Specialk. Preussen u. Thüring. Staaten," vol. vi., pt. 3, pp. 17–19, pl. i., figs. 4, 5.
,,	,,	A. S.-Woodward, 1886.	"Geol. Mag. N. S.," Decade 3., vol. iii., p. 216, pl. vi., figs. 19–22.

A single tooth of the upper jaw, of this species, is included in the collection forwarded by Prof. Hutton from the Otago Museum. The crown consists of three principal cones; the largest is 0·4 inch in height, 0·3 inch in breadth at the base.

The lateral margins converging to an acute apex inclined obliquely backwards. Surface of cone convex, with margins smooth and thin. At the base of the anterior margin is a series of six or seven minute denticulations connecting it with the base. The second cone is much smaller than the first; its length is 0·15 inch, and its breadth at the base is equal to the length. It is more obliquely inclined backwards than the larger cone. The third cone is still smaller; it is broken off, but its form and size are indicated on the matrix. Its point is much more obtuse than the others. The surface of the whole is enveloped in smooth shining enamel. The root is large and massive, equalling in depth the height of the largest cone. It is compressed laterally.

The example now described approaches most nearly in form to the tooth figured by Prof. Agassiz ("Rech. sur les poiss. foss," vol. iii., pl. xxvii., fig. 9) as *Notidanus recurvus*, which appears, as already pointed out by Mr. A. S.-Woodward ("Geol. Mag.," Decade 3, vol. iii., p. 217), to be an upper tooth of this species. The specimen in the collection of Dr. Reed, now in the York Museum, derived from the Red Crag of Woodbridge, in Suffolk, and figured by Mr. A. S.-Woodward (*op. cit.* pl. vi., fig. 21), is almost identical in size and proportions with the one from New Zealand. This species, which appears to have as wide a range over the surface of the globe as any species hitherto recorded, has been found in the Tertiary beds throughout Europe; it is recorded in America, and the specimen now described extends its range to the opposite extreme of the world.

Formation.—Oamaru formation.

Locality.—Cave Valley, Oamaru; Coleridge Gully.

Ex coll.—Prof. F. W. Hutton, Otago, New Zealand.

Notidanus marginalis, Davis.

(Pl. vi., figs. 7, 8.)

Teeth of both the upper and lower jaws have been found of this species. They were obtained by Mr. J. Davies Enys, from the Oamaru formation at Castle Hill Station. The teeth from the upper jaw are moderately large and thick. The crown consists of one large cone, occupying two-thirds the breadth of the tooth, the remaining posterior third consisting of about a dozen small denticulations diminishing in size backwards, excepting the two first, which are very small. The large cone rises 0·4 inch from the base, and is inclined backwards; the external and internal surfaces are convex; its posterior margin straight and smooth; the anterior one is convex, very long, and serrated from the base almost to the apex; the serrations are largest midway between the two extremities, towards which they gradually diminish in size. The external surface of the base of the crown is slightly curved inwards; a corresponding convexity characterizes the internal

surface. The line dividing the crown from the root ascends higher on the internal than on the external surface, in this respect conforming to the ordinary character of the selachians. The root descends 0·1 inch; on the external surface its lower margin is arched upwards, parallel to the outline of the base of the crown, from which it is somewhat retrogressive; the internal surface of the root is prominently convex; the median portion is 0·2 inch in depth. The breadth is 0·8 inch.

This tooth is readily distinguished from the upper teeth of *Notidanus primigenius*, from the Cave Valley deposits, by its single large cone, the great length of its anterior margin, and the comparatively small size of the root. These features also serve to distinguish it from other species previously described.

The teeth of the lower jaw are thinner and less robust than those of the upper one, the crown is more slender and the root deeper. The breadth of the tooth figured is nearly 1·0 inch; the height of the crown is 0·25 inch, and the depth of the root 0·2 inch. The external surface is straight or very slightly concave, that of the internal one slightly convex. There are five cones decreasing in size backwards; they have an oblique inclination in the same direction. The anterior margin at the base of the first or largest cone has five or six serrations, decreasing in size towards the root, and at the posterior extremity of the tooth there is also a minute denticulation. All the cones are smooth and convex on each surface. The root is moderately large, but thin; its internal surface at first produced rapidly, declines towards its base and thins out to a knife like edge. It rises higher on the internal than on the external surface.

The teeth of the lower jaw bear a tolerably close resemblance to those of *Notidanus serratissimus*, Agass. ("Poiss. Foss.," vol. iii., p. 222, pl. xxxvi., figs. 4, 5), and also to the tooth figured by Mr. A. Smith-Woodward (*op. cit.*, fig. 23), from the London clay. The teeth of the mandible of *N. primigenius*, Agass., might also be confounded with it; but its association in the same beds with the maxillary teeth described above leads to the inference that they were associated and belong to the same species, and if this be the case, the resemblance of the teeth of the lower jaw to those of other species must be received as accidental; the teeth of the upper jaw are distinctly separated from any others previously described.

Several single denticles, probably belonging to this species, occur in the collections received from the Canterbury Museum, Christchurch. They were obtained from the Oamaru series at Coleridge Gully. The denticles are from the teeth of the lower jaw, and the same size as the larger denticles of the specimen figured.

Formation.—Oamaru formation and Waipara formation (Te Aute series).

Locality.—Castle Hill Station, Canterbury; Waipara; Tata Island Limestone, Nelson.

Ex coll.—J. Davies Enys, Esq., Canterbury, New Zealand; Canterbury Museum, Christchurch.

Notidanus dentatus, Smith-Woodward.

(Pl. vi., figs. 9–12.)

A. Smith-Woodward, 1886. "Geological Magazine," Dec. 3., vol. iii., p. 214, Pl. vi., figs. 17, 18.

In 1876 Sir J. Hector sent a small collection of fossil-fish remains to the British Museum. They were obtained from Amuri Bluff, New Zealand; and amongst them were specimens of the teeth of a large Notidanus. These were described by Mr. Smith-Woodward, in the Paper cited above, in the following terms:—

"The lower tooth exhibits three small denticles in front of the principal cone, the first being the largest, and having a recurved apex, the second slightly smaller, with straight, but backwardly-directed point, and the third very much more minute. Behind the principal cone, which is scarcely more robust than that immediately following, there are ranged three other cones, of gradually diminishing size; and posterior to these a minute denticulation is visible. In the upper tooth the principal cone appears more definitely contrasted with the others. In front there are two distinct denticles, the first being three times the size of the second; and the principal cone itself is placed almost vertically with respect to the base-line of the crown, although its anterior edge has a much less abrupt slope than the posterior. Behind this there are three other cones rapidly diminishing in dimensions: the first somewhat inclined backwards, and three-fourths the size of the principal cone; the second backwardly directed at a corresponding angle, but only about one-third as large as the first; and the third a minute, broad, acuminate denticle. Though now imperfectly shown, the base-line of the crown was obviously arched; and the remains of the root indicate the usual configuration and robust proportions of an upper tooth."

Two specimens of the teeth of the lower jaw are figured on Pl. vi., figs. 11, 12. They are from the Geological Survey Collection forwarded by Sir James Hector, M. D. The teeth are larger than the tooth described by Mr. Smith-Woodward, but in other respects appears to be the same. The tooth represented by fig. 11 has nine denticles preserved; and the other one has the still larger number of eleven; the type described by Mr. Smith-Woodward has not more than eight denticulations.

The species thus described most closely approximates to the characters possessed by *N. pectinatus* from the English chalk. The latter, however, is much smaller, and differs in possessing a longer series of cones behind the principal. It is also stated to possess characters in common with a small species at present existing in the seas off the coast of Patagonia, described by Mr. S. Garman

("Bulletin, Essex Institute," vol. xvi., pp. 56, 57: 1884) as a new species, *N. pectorosus.* The latter is a small species, only sixteen inches in length, and has one cusp fewer than *N. dentatus.*

Formation and Locality.—Waipara formation; Amuri Bluff; Waireka series; Amuri Bluff (Sir J. Hector).

Ex coll.—British Museum, Natural History, Cromwell-road, London; Geological Survey Collection, Wellington.

(B)—BATOIDEI—RAYS.

Family. **TRYGONIDÆ.**

Genus. **Trygon.** Adanson.

The pectoral fins are uninterruptedly continued to, and are confluent at, the extremity of the snout. Tail very long, tapering, armed with a long arrow-shaped, barbed spine. Body smooth or with tubercles. Vertical fins none. Nasal valves coalescent into a quadrangular flap. Teeth flattened.

Trygon ensifer, Davis.

(Pl. vi., figs. 13–15.)

A number of fragmentary remains of the teeth and dermal osseous tubercles, together with specimens in good preservation of the spines of a species of Trygon, have been found in several localities in the Oamaru and the uppermost beds of the Waipara formations. Calculating from a comparison of the size of the spine and teeth with those of an existing species, it is probable that the fossil-fish attained a size of about one foot in diameter. It is somewhat difficult to distinguish between the dermal tubercles and the teeth. Certain patches of sub-quadrate ossicles, with one angle of the square pointing forwards, are regarded as teeth, whilst the larger proportion of the specimens are more or less round, with flattened surfaces, and probably pertained to the dermal series of tubercles.

The teeth vary in size from 0·1 inch to 0·05 inch in width. They have an imbricated arrangement, the anterior point of a tooth overlapping slightly the margins of those in front of it. The surface where not worn is prominent and rounded, but where the teeth have been much used they are worn smooth, and present an even pavement-like arrangement. They appear to be firmly attached

to the jaws, a portion of the bony substance of which has, in some cases, broken away, and remains attached to the teeth. The teeth are covered with enamel. The under surface is more or less hollow.

The dermal tubercles have a circular outline with a convex surface. Where they present an hexagonal form they have the appearance of having had all the corners rubbed off. The surface is often considerably worn. The depth of the tubercles is small; and they are deeply concave beneath. They present much difference in size, individual specimens being 0·2 inch in diameter.

A spine, which is nearly perfect, is 0·6 inch in length and 0·1 inch across the base. It is erect, compressed; the lateral margins are armed with a row of firmly-attached recurved denticles, which extend from the point two-thirds the length of the spine; towards the base they become smaller, and gradually disappear. The anterior and posterior surfaces are slightly convex, with a smoothly enamelled surface. An internal canal extends from the base towards the apex. A second example (fig. 15), is longer and differs from the other which is represented, in the much smaller denticulation of the margin; it is from the chalk series of Amuri Bluff, and has been forwarded by Sir James Hector, M.D., with others from the Survey Collections at Wellington Museum.

Prof. L. Agassiz states that two species of Trygon have been found, viz. *T. gazzolæ* and *T. oblongus* ("Poissons Fossiles," vol. iii., p. 382**). They are from the strata of Monte Bolca, but are not described. The specimens which are the subject of this description are very similar to some of the existing forms. It is proposed to designate this species by the name *Trygon ensifer*, having reference to the small sword-like spine.

Formation.—Uppermost bed of the Waipara and the Oamaru formations; Te Aute series and Chalk series.

Localities.—Waipara, Wekapass; Colebridge Gully; Broken River; Castle Hill, Canterbury; Tata Island Limestone, Nelson; Amuri Bluff; Kakahu; Coleridge, Trelissic, Canterbury; Waihola series, Otago.

Ex coll.—Canterbury Museum, Christchurch; J. D. Enys, Esq., &c., Geological Survey Collections, Wellington.

Family. **MYLIOBATIDÆ.**

Genus. **Myliobatis.** DUMERIL.

The disk is very broad, in consequence of the great development of the pectoral fins, which, however, leave the sides of the head free, and reappear at the extremity of the snout as a pair of detached cephalic fins. Viviparous, teeth hexangular, large, flat, and tesselated, those in the middle much broader than long,

several narrower series on each side. Tail very long and thin, with a dorsal fin near its root; generally a serrated spine behind the fin.

A large number of specimens of this genus have been found in the Oamaru formations at Broken River, Curiosity Shop, Castle Hill, and other localities. They present characteristics which appear to necessitate their division into three species. There are probably more than this number, but their isolated or detached state of preservation renders their determination difficult.

Myliobatis plicatilis, Davis.

(Pl. vi., figs. 16–19.)

A large number of teeth, all disconnected from each other, and many of them broken, have been found in the Oamaru formation; they are straight or very slightly arched, and vary from 0·3 of an inch in breadth to 1·8 inch. The larger ones are generally much worn by attrition on the upper surface, but, as might be expected, not all to the same extent. The upper surface, where not much abraded, is smooth and covered with glistening enamel; in examples in which the abrasion has proceeded to a greater extent the surface has a coarse osseous appearance. An example, 1·7 inch in breadth is 0·45 inch in length in the centre, diminishing towards each lateral extremity to 0·4 inch. The base of the crown descends obliquely backwards, the division between the crown and root being marked by a prominent ridge which encircles the whole tooth. The root is slightly less in breadth and length than the crown; it is composed of a variable series of lamellæ descending from the base of the crown, each parallel with the others and separated by an interstice equal to the width of the plate. The number of lamellæ depends to some extent on its age: the small specimens have comparatively few, whilst those of mature growth are possessed of from thirty to forty. The anterior portion of the crown projects beyond the root, whilst behind the root extends a similar distance beyond the crown—an arrangement similar to that found in existing species, and serving to attach and interlock the succeeding teeth. The lateral extremities of the tooth are angular, the median portion produced so as to fit to the small lateral teeth. Several of the latter occur, one 0·4 inch in length, the same length as the specimen described above, from the centre of the palate is 0·1 inch in breadth in the middle, tapering to a point before and behind; others are slightly broader than this in the median part. The roots of the small lateral teeth have two or three parallel antero-posterior lamellæ, or ridges. Others of the small lateral teeth are angular along one of the lateral margins, and convex on the other, and were doubtless the external components of the palate; they are in other respects similar to, and the same size as, those already described.

This species is readily distinguished from those previously described by the

comparatively small breadth of the crown as compared with its length. This character separates it from *Myliobatis goniopleurus*, Agassiz ("Poiss. Foss.," vol. iii., p. 319, pl. XLVII, figs. 9, 10), obtained from the London clay of Sheppey, in which teeth of the same length are nearly twice the breadth. From *M. toliapicus*, Agass., (*op. cit.*, p. 321, pl. XLVII., figs. 15–20), it may also be distinguished by its narrow four-sided lateral teeth, those of *M. toliapicus* being regularly six-sided. The fossil species bears a passing resemblance to the existing *M. aquila*, but differs from it in the form of the large central plate, which in the recent species is curved in outline, with a much shorter crown compared with its length.

Formation.—Oamaru formation.

Locality.—Curiosity Shop; Broken River; Castle Hill Station, &c.; Coleridge; Trelissic; Tokmairiro Limestone, Waihola Gorge.

Ex coll.—Canterbury Museum: J. D. Enys, Esq.; Geological Survey Collection, Wellington.

Myliobatis arcuatus, Davis.

(Pl. VI., figs. 20, 21.)

A second species of this genus from the Oamaru beds is represented by a large number of specimens. It is smaller than *Myliobatis plicatilis*, and differs from it in the shortness of the crown as compared with its breadth and in its highly-curved outline. A fully mature and much abraded example is 1·3 inch in greatest diameter between the two lateral extremities, the length of the crown being 0·2 inch. The surface of the crown is somewhat rough and fibrous. A ridge, similar to the one on *M. plicatilis*, indicates the division between the root and the crown, whilst the latter shows a considerable obliquity in the relative position of the crown and root; the species now described is more erect, and its thickness greater.

Formation and Locality.—Oamaru formation; Castle Hill Station.

Ex coll.—J. D. Enys, Esq.; Cambridge Museum.

Myliobatis altus, Davis.

(Pl. VII., figs. 1, 2.)

Specimens of parts of two palates have been obtained from the Oamaru formation at Broken River, they are each fragmentary, but exhibit three teeth *in situ* in one specimen, and two in the other. The length of the teeth is 0·5 inch, the breadth is not preserved, the height between the crown and the root is 0·5 inch. They are large and massive; the surface of the crown between the lateral extremities is deeply convex, and in the antero-posterior direction the palate is also

convex. The surface of the crown is smooth, with a more or less fibrous appearance. The under surface of the root is devoid of lamellæ, but presents an open and porous structure. The root occupies about one-fourth the entire height of the tooth. The teeth decrease in thickness towards the margin, and in the specimen now described there is attached thereto a single row of lateral teeth. If there were other rows they have disappeared. The lateral teeth are small, 0·4 inch in length, and not more than 0·1 inch across laterally.

The presence of the lateral plates prove these teeth to belong to a species of Myliobatis, and the thick convex median teeth appear to separate this from any other species previously described. The massive character approaches most nearly to that of *M. regley*, Agass. ("Poissons Fossiles," vol. iii., p. 320, pl. XLVI., figs. 6–11), obtained from the neighbourhood of Brussels in Belgium. The latter, however, is founded on a single fragment without lateral plates, and all the edges broken off, so that it is very difficult to compare the specimens now described with those of Agassiz species. So far as the form of the coronal surface is concerned the sutures dividing the large median plates in *M. regley* are straight, whilst in this species they are curved. The under surface of the root in the former is lamellated; in this species lamellæ are absent.

Formation and Locality—Oamaru formation: Broken River.

Ex coll.—Canterbury Museum, Christchurch, New Zealand.

Sub-order 2. Holocephala.

Family. **CHIMERIDÆ.**

Callorhyncus hectori, Newton.

Newton, E. T., 1876, "Quart. Journ. Geol. Soc.," vol. xxxii., p. 329, pl. XXI., figs. 6–9.

(Pl. VII., figs. 14, 15).

The single specimen on which this species is founded was placed in the British Museum by Sir J. Hector. It is a right maxilla, a little more than one inch in length and three-fourths of an inch in width at its posterior widest part. The lower or oval surface is exposed, the upper one imbedded in the matrix. The oval surface of the maxilla is provided with a single tooth, composed of dentinal substance; posteriorly this appears to pass into the substance of the bone; but anteriorly it is prominent and divides into two divaricating branches with a depressed area between. These are worn by impact with the opposing surface of

the single tooth of the mandible. A comparison of the specimen with the jaws of the existing *Callorhynchus antarcticus* shows that there is a close resemblance between the two. The tooth of the New Zealand fossil is flatter, larger, and has longer anterior prominences than the existing species; and whilst it is regarded by Mr. Newton as undoubtedly being the same genus, he considers it forms a different species which he has distinguished by appending the name of Sir J. Hector.

Formation.—Black Grit series; Cretaceo-Tertiary.

Locality.—Amuri Bluff, New Zealand.

Ex coll.—British Museum (Natural History Department); Geological Survey Collection, Wellington.

Ischyodus brevirostris, Agassiz.

Newton, E. T., 1876. "Quart. Journ. Geol. Soc.," vol. xxxii., p. 326, pl. xxi., fig. 5.

(Pl. vii., figs. 10–13.)

The unique specimen described by Mr. Newton is from the Amuri Bluff Beds, and was deposited in the British Museum by Sir J. Hector. It is the right mandible, and its outer surface is embedded in the matrix, and part of the narrow extremity of the tooth is broken off. It is described as in all essential respects similar to the teeth of *Ischyodus brevirostris*, named, but not described, by Prof. L. Agassiz ("Rech. sur les Poiss. Foss.," vol. iii., p. 344). The English types of Agassiz are from the phosphatic deposits of Cambridge. The New Zealand example is shorter along the oval margin, and the centre of the tooth is more prominent than in the specimens from the Cambridge Greensands.

Three additional specimens are represented from the collections of the Geological Survey. Figs. 11 and 12 exhibit the under surface of the jaw, and fig. 13 a fragment of the upper surface.

Formation.—Coal-Beds, Cretaceo-Tertiary formation.

Localities.—Amuri Bluff Beds; Kakohu River, South Canterbury.

Ex coll.—British Museum (Natural History Department); Geological Survey Collection, Wellington.

Sub-class II.—TELEOSTEI.

Order 1.—Acanthopterygii.

Division I.—Acanthopterygii Perciformes.

Family IV. **SPARIDÆ.**

Genus. **Sargus.** Cuvier.

Agassiz, L., 1833–4. "Rech. sur les Poissons Fossiles," vol. iv., p. 168.

The genus Sargus is restricted to the species of Sparides, which have rounded molars posteriorly. The anterior teeth of each row are disposed in a single row on the extremities of the intermaxillaries and the inferior maxillaries. They are compressed and spatulate, the extremities truncated like the incisors of the Rodents.

Sargus laticonus, Davis.

(Pl. vii., figs. 3–8.)

A large number of teeth have been found in the limestone beds at Coleridge Gully, Broken River, Castle Hill, and other places. They vary considerably in form and size, ranging between a round, conical, upright tooth, to others which are oval in section at the base with spatulate crown, compressed antero-posteriorly, and presenting an appearance similar to the incisors of the recent Sargus. The apex of the tooth is in most instances worn off by attrition, often to such an extent as to expose a section of the tooth; where the apex is still preserved it is blunt and rounded. The teeth are all enveloped in a strong and thick coating of enamel, with a polished smooth surface. An example (fig. 3) of the round conical form of comparatively large size is 0·5 inch in length from the base of the crown to the apex, the latter bluntly rounded, and the base is 0·3 inch in diameter. The cone is slightly twisted; otherwise it ascends with a tolerably uniform contour. The base of the crown is slightly contracted, and forms a well-defined line of division between the crown and the root. The root in this specimen is broken off; but in others of similar form it is equal in depth to the height of the crown (fig. 4). Its upper part, where joined to the crown, is contracted and less in diameter than the base of the crown; it increases lower down, and becomes considerably wider than the crown, still preserving its rotund section. The outer surface of the

root is fine and fibrous, rather thin as compared with the enamel of the crown, which will probably account for their being so frequently detached. The interior of the root is apparently composed of a more or less spongy mass, hollow in the centre. The hollow ascends the crown, gradually disappearing towards the point. The height of the conical tooth now described, as compared with its diameter, at the base of the crown, bears the proportion of five to three; other examples vary as four to three; and instances are not unfrequent in which the diameter equals or even exceeds the height, excluding those specimens which are worn.

An example selected from the opposite, or most compressed type of the series (fig. 5), is 0·3 inch in diameter at the base of the crown, between the two sides of the tooth, and 0·15 from front to back; the height of the crown on the external surface is 0·45 inch, being greater than the internal one, the margin of which is slightly curved upwards. The external surface is convex, the lateral margins rounded, and the internal surface is concave, sometimes quite spatulate. The apex is usually considerably worn and angular; occasionally it is obtusely pointed. The base of the crown is slightly contracted laterally; and the root assumes a form similar to that of the teeth, with conical crowns (fig. 6), except that its diameter does not equal that of the breadth of the crown. Between the two forms described every gradation may be found existing in the collections at my disposal. The most extreme of the compressed type of teeth is a specimen (fig. 7), in the collection of J. Davies Enys, from Castle Hill Station, near Canterbury. It is 0·4 inch in breadth, very thin in section, and only 0·25 inch in height. It is considerably worn, and has probably belonged to an aged fish.

This group of teeth appears to be closely related to the fishes comprised in the family Sparidæ, whose dentition consists either of cutting teeth in front of the jaws or molar teeth on the sides; generally palatal teeth are absent; but in some instances, as in the genus Sargus, in addition to incisors in the anterior part of the lower jaw and the intermaxillaries, there are rounded, flat teeth, occupying an intermediate position on the palates. The teeth from New Zealand differ from those of the existing Sargus in the variety of their form, and in the absence of the flat, circular palatal teeth. The teeth of Dentix, Agassiz ("Poiss. Foss.," vol. iv., p. 143) are long, conical and pointed, disposed in a single row. In the sharply-pointed character they differ from the obtusely-pointed, conical teeth now described, and are readily distinguished from the compressed incisor form. They have probably a greater resemblance to the existing genera Sphærodon or Lethrinus, which have canine teeth in front and a single series of broadly-conical, molar-like teeth on each side; or to some of the genera of the Cantharina, in which the front teeth have a more or less broad, cutting surface, sometimes lobate. The fossil genus Sparnodus, Agassiz ("Poiss. Foss.," vol. iv., p. 155), from the Tertiary strata of Monte Bolca, possesses teeth which are large, conical, very strong, and obtuse, eight occupying the front part of each jaw. They have

usually been found associated with the remaining portions of the skeleton of the fish. Some of the teeth described above, though isolated and detached from any part of the skeleton of the fish, appear to approach very nearly to the teeth of this genus. But the presence of a large proportion of the spatulate cutting teeth prevents their association with the genus, whilst they indicate a clear relationship with the genus Sargus, in which it is proposed they shall be incorporated with the specific distinction *Sargus laticonus.*

Three examples of Otoliths (fig. 21) occur associated with the teeth of this species. They are 0·4 inch in length, the upper surface convex, with radiating sulci, most pronounced towards the margin, and a ridge along the median line; the under surface is slightly concave.

Formation.—Oamaru system; Mount Brown series.

Localities.—Coleridge Gully; Broken River; Castle Hill Station, &c.; Coleridge; Trelissic; Canterbury.

Ex coll.—Canterbury Museum and College; J. D. Enys, Esq.; Otago Museum; Geological Survey Collections, Wellington.

Class.—MAMMALIA. Sub-class.—CETACEA.

Family. **ZEUGLODONTIDÆ.**

Genus. **Squalodon.** GRATELOUP.

Squalodon. GRATELOUP. "Actes Acad. Roy. Sci., Bordeaux," 1840, p. 208.
Phocodon. AGASSIZ, . "Rech. sur les Poissons Fossiles," vol. iii., p. 255.

Molar teeth, with a semi-elliptical crown, strongly compressed laterally, the cutting edge divided into semi-elliptical lobes in one plane, the middle one largest, the lateral gradually diminishing to the anterior and posterior ends; enamel longitudinally marked with small irregular ridges; root with two or three fangs. (M'Coy.)

This remarkable genus forms part of the Zeuglodontidæ, a family of extinct carnivorous whales, whose remains have been found in America, Europe, and Australia; in each instance in strata of Tertiary age. The Zeuglodonts of America are from the Eocene formations; in Europe the family is represented by *Squalodon grateloupi* von Meyer, from the French Miocene beds near Bordeaux, the only other examples are from beds of similar age at Léognan, in Gironde. (M. Grateloup's type was a jaw from those beds, supposed to be of an animal intermediate between sharks and saurians); and St. Jean de Videy, Herault, and in Austria its remains have been found near Linz. Teeth of Squalodon, or

Phocodon, have also been discovered in the Miocene strata of Malta. More recently Prof. M'Coy has described a species of Squalodon from the Miocene sands of Castle Cove, Cape Otway Coast, Australia, ("Geol. Mag.," vol. iv., p. 145, pl. viii., fig. 1, 1867, and "Proc. of the Palæontology of Victoria," Dec. 2, pl. xi., fig. 1, 1875). The Australian specimens are considerably smaller than those found in Europe and America, they may further be distinguished by the length of the root in proportion to the size of the crown; and whilst the Zeuglodonts of America have the roots divided into two widely-separated fangs, equalling in depth the height of the crown, those of Australia resemble *Squalodon grateloupi* in having the root single, and only marked by a median vertical sulcus ascending to the base of the crown. The specimen from the Oamaru formation of New Zealand possesses characters which appear to render necessary its location as a distinct species.

Squalodon serratus, Davis.

(Pl. vii., fig. 9.)

This species is represented by a single tooth from the White Rock River Quarry. It is enveloped in a matrix of light-coloured calcareous sandstone. The crown only is exposed, and consists of a number of cones, of which six are visible, having obtusely-pointed apices. The root, if present, is hidden in the matrix. The base of the crown, so far as exposed, is 0·8 inch in breadth; the central and most prominent cone rises to a height of 0·75 inch; it is erect, convex, depressed towards the margin, which is thin and slightly crenulated. Four other denticles extend from the central one on the left side, diminishing in height and size as they recede; they are similar in form to the median one, except that they exhibit a tendency to incline towards it. On the opposite side only one denticle is exposed: it corresponds in form and size to the first denticle to the left of the median one. The specimen has been exposed by cutting away the matrix as far as it appears safe to proceed. The enamel is so fragile that to attempt to work further would probably result in the entire breaking-up of its surface and the ruin of the specimen. There appears every probability, however, that if the tooth were fully exposed it would be found that a series of secondary denticles would extend on the right side of the central one, more or less similar to those on the left. The surface of the crown is ornamented by a rugose network of striations, coarse towards the base, becoming finer towards the summit, and gradually disappearing near the margin.

This fossil tooth presents a certain resemblance to those of the family of Gymnodonts, comprising the existing marine genera Tetrodon and Diodon, and

represented in a fossil state in the Tertiary Limestones of Monte Bolca and Licata by the genus Diodon, and by a second genus Enneodon, from the Tertiary beds of Monte Postale. The existing genera comprise about seventeen species, inhabiting the tropical parts of the Atlantic and Pacific seas. Tetrodon is characterized by having a dental arrangement, consisting of a plate attached to each ramus of the two jaws, divided by median sutures, whilst Diodon has only a single undivided dental palate to each jaw. It consists of a semicircular plate, extending backwards into the mouth, in the form of a palate, the front edge is slightly produced and somewhat beak-like, the teeth also encircle the jaw and extend along its outer surface. This dental arrangement is admirably adapted to break up masses of coral or the hard shells of molluscs and crustaceans on which the fishes feed.

In considering the relationship of this peculiar tooth, its series of denticles suggests an affinity with Notidanus. In the latter, a more or less extended root supports a number of conical denticles, the anterior one being, as a rule, the largest, followed posteriorly by others similar in form, but diminishing in size as they recede from the principal one; the whole are inclined, with considerable obliquity, backwards. In this specimen the principal cone is erect, and occupies a median position, with a number of denticles on each side, the latter diminish in size as they recede from the centre like Notidanus; but instead of being inclined obliquely from the principal cone they bend over towards it. The circumstance of the secondary denticles extending from both sides of the principal one sufficiently asserts the difference between the two.

The specimen now described is, in many respects, similar to those of the existing Diodons: it differs from them in others. The surface exposed is the outer one, and its series of denticles, rising from an undivided base, apparently without a root, closely approximate to that of Diodon; but whereas the latter is undivided quite to the cutting-edge, this species is so deeply serrated as to form a series of large and prominent denticles. In this respect it resembles to a remarkable degree the teeth of *Pristodus falcatus* ("Trans. Royal Dublin Society," vol. i., ser. 2, p. 519, pl. LXI., figs. 17–22). These latter were obtained from the uppermost beds of the mountain limestone series of Yorkshire. The tooth of the upper jaw is semicircular in outline, diminishing in height posteriorly, and its denticulated cutting-edge extended obliquely forwards, from above downwards. The lower jaw was enveloped in a similar bony investment; the median portion of the tooth is produced to form a beak-like prominence, the remaining portion of the crown surface being smooth and even.

Notwithstanding the external resemblance of the tooth now described to those of Pristodus, it appears to possess still greater relationship with the genus Squalodon found in the Miocene beds of Victoria. *Squalodon wilkinsoni* (M'Coy), (*op. cit.*), slightly exceeds 2·5 inches in height, of which the crown occupies 0·75 inch; its breadth is under 1·0 inch. The median denticle is large in proportion

to the lateral ones; of the latter there are two denticles on the anterior surface, and three on the posterior one. The latter denticles diminish rapidly in size, and the surface is marked with coarse, rough, irregular sulci. The New Zealand species closely resembles that described by M'Coy, in the form of the median denticle and the surface-markings; it differs in the number of lateral denticles, or cones, and also in the convex outer margin of the crown; for whilst it is curved from the median denticle backwards the Australian specimen is nearly straight. The imperfection of the tooth renders its identification a little difficult; but the balance of its several characters appears to indicate its relationship with the genus Squalodon rather than with Pristodus, and it is proposed to include it, provisionally, in that genus, with the specific appellation, *serratus.*

Formation.—Oamaru formation.

Locality.—White Rock River Quarry, New Zealand.

Ex coll.—Canterbury Museum, Christchurch.

List of Species and Reference to Pages.		Coleridge Gully.	Castle Hill Station.	Curiosity Shop.	Deep Creek, Blue Skin.	Kaikoura Peninsula.	Wekapass.	Waihoa Falls.	White Rock River Quarries.	Waitaki.	Marnawhenna.	Awamoko.	Cave Valley, Oamaru.
Galeocerdo aculeatus, Davis,	p. 8	×	×	...	...	...	...	...	...	...	...	...	...
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,, robustus, Davis,	,, 13	...	...	...	...	...	...	...	...	×	...	...	...
Otodus obliquus, Agassiz, ...	,, 15	...	...	...	...	...	...	...	...	...	...	...	...
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,, incurva, Davis, ...	,, 17	×	...	×	...	×	...	...	×	×	...	...	...
,, ensiculata, Davis, ...	,, 18	...	...	..	...	...	...	...	...	...	...	...	...
,, marginalis, Davis, ...	,, 19	...	...	...	...	×	×	...	...	...	...	...	...
,, attenuata, Davis, ...	,, 19	×	...	...	...	...	...	...	...	...	...	...	...
,, lanceolata, Davis, ...	,, 20	×	×	...	...	...	...	...	...	...	...	...	...
,, carinata, Davis, ...	,, 21	...	...	...	...	×	...	...	...	...	...	...	...
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,, hectori, Davis, ...	,, 21	...	...	...	...	...	...	...	...	...	...	...	...
Odontaspis acuta, Davis, ...	,, 22	...	...	×	...	...	...	...	...	...	...	...	...
,, exigua, Davis, ...	,, 23	×	×	...	...	...	..	...	...	...	...	...	...
,, kaikoraensis, Davis,	,, 24	...	...	...	...	×	...	...	...	...	...	...	...
,, sulcata, Davis, ...	,, 25	...	...	...	...	...	...	...	...	...	...	...	...
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,, recta, Davis, ...	,, 27	...	×	...	...	...	...	...	...	...	...	...	...
,, enysii, Davis, ...	,, 28	...	...	...	...	...	...	...	...	...	...	...	...
,, acuminata, Davis,	,, 29	...	×	...	...	...	...	...	...	...	...	...	...
,, grandis, Davis, ...	,, 30	...	...	×	...	...	×	...	...	...	...	...	...
,, fastigiata, Davis,...	,, 30	×	...	...	...	...	...	...	...	...	...	...	...
,, subvexa, Davis, ...	,, 31	...	...	...	...	...	...	...	...	...	...	...	...
,, lata, Davis, ...	,, 32	...	...	...	...	...	...	...	...	...	...	...	...
Notidanus primigenius, Agassiz,	,, 33	×	...	...	...	...	...	...	...	...	...	...	...
,, marginalis, Davis,	,, 34	...	×	...	...	...	...	...	...	...	...	...	...
,, dentatus, S.-Woodw.,	,, 36	...	...	...	...	...	...	...	...	...	...	...	...
Trygon ensifer, Davis, ...	,, 37	×	×	...	...	...	×	...	...	...	...	...	...
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,, arcuatus, Davis,...	,, 40	...	×	...	...	...	...	...	...	...	...	...	...
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Sargus laticonus, Davis, ...	,, 43	×	×	...	...	...	...	...	...	...	...	...	...
Squalodon serratus, Davis,...	,, 46	...	...	...	...	...	...	...	×	...	...	...	...

LITIES IN WHICH THEY OCCUR.

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Waipara.	Oamaru.	Hogsback.	Kakahu River.	Gorge Hill, Pareora.	Mohaka Crossing, Napier.	Raglan, Auckland.	Amuri Bluff.	Waihola Gorge, Otago.	Esk River, Hawkes Bay.	Cape Foulwind.	Nelson.	Near Cobley's Creek.	Broken River.	Trelissic, Canterbury.	Mercer, Auckland.	Mokau Valley.	Wharaema.
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EXPLANATION OF PLATE I.

PLATE I.

Figs. 1–3, Galeocerdo aculeatus. Davis.

1. Posterior tooth. *a.* External surface. *b.* Internal surface. *c.* Side view.
   1 *a.* Magnified 3 diameters.
2. Anterior tooth. *a.* External surface. *b.* Internal surface.
3. Small posterior tooth.

Coleridge Gully, ... *Ex coll.* Canterbury Museum, Christchurch.

Figs. 4–6, Carcharodon angustidens. Agassiz.

4. Posterior tooth. *a.* External surface. *b.* Internal surface. *c.* Side view.
5. Anterior tooth. Internal surface.
6. Another specimen. Internal surface.

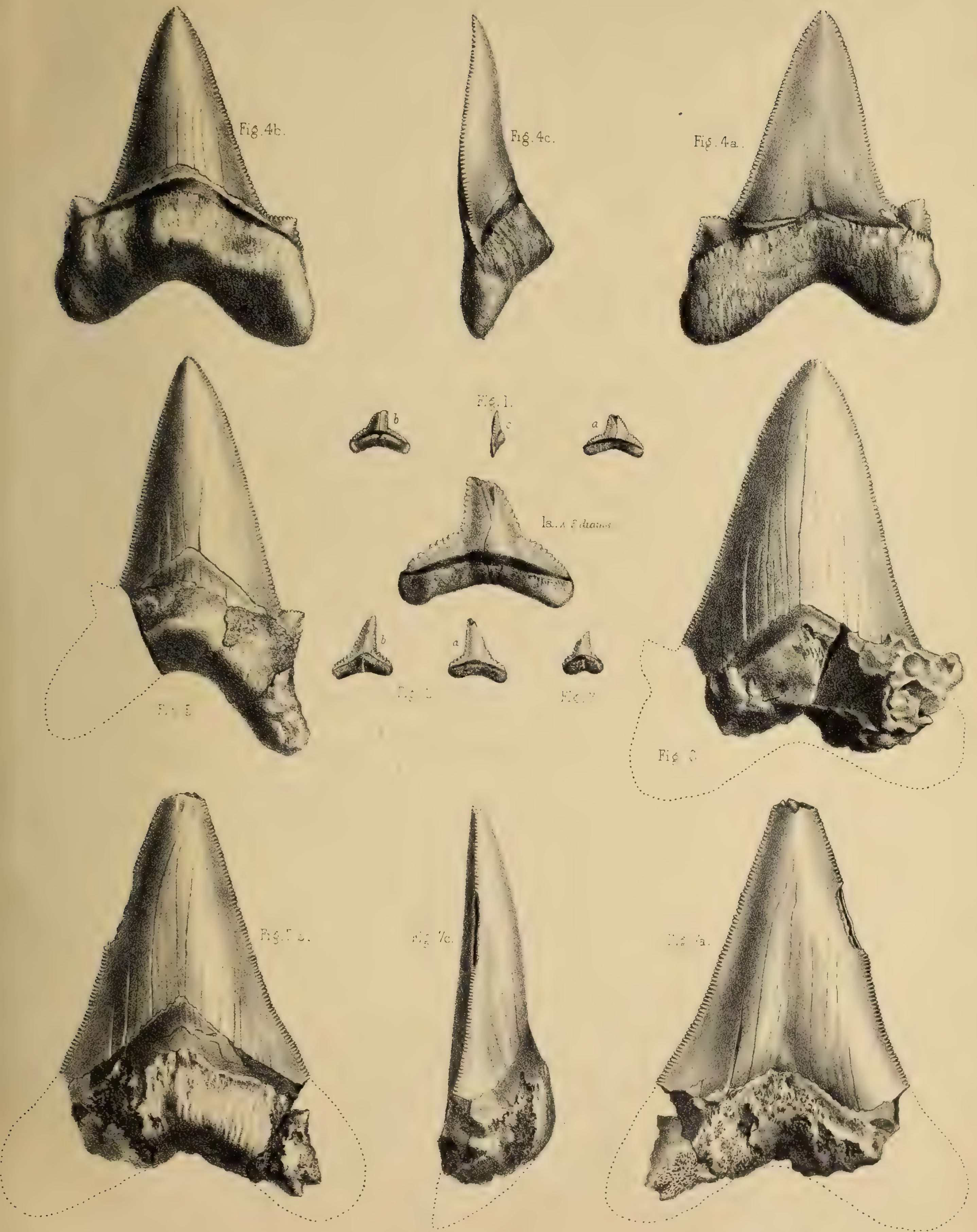
4. Waihoa Forks, ... *Ex coll.* Canterbury Museum, Christchurch.
5. Otago, ... *Ex coll.* Otago Museum.
6. Wekapass, ... *Ex coll.* Canterbury Museum, Christchurch.

Fig. 7, . Carcharodon robustus. Davis.

a. External surface. *b.* Internal surface. *c.* Side view.

Waitaki, ... *Ex coll.* A. M'Kay, Otago Museum.

Plate I.



J W Davis direxit W H Crowther del.

Mintern Bros imp

EXPLANATION OF PLATE II.

PLATE II.

Fig. 1, Carcharodon megalodon. Agassiz.

a. External surface. *b*. Internal surface. *c*. Side view.

Cape Foulwind, Nelson, . *Ex coll.* Wellington Museum.

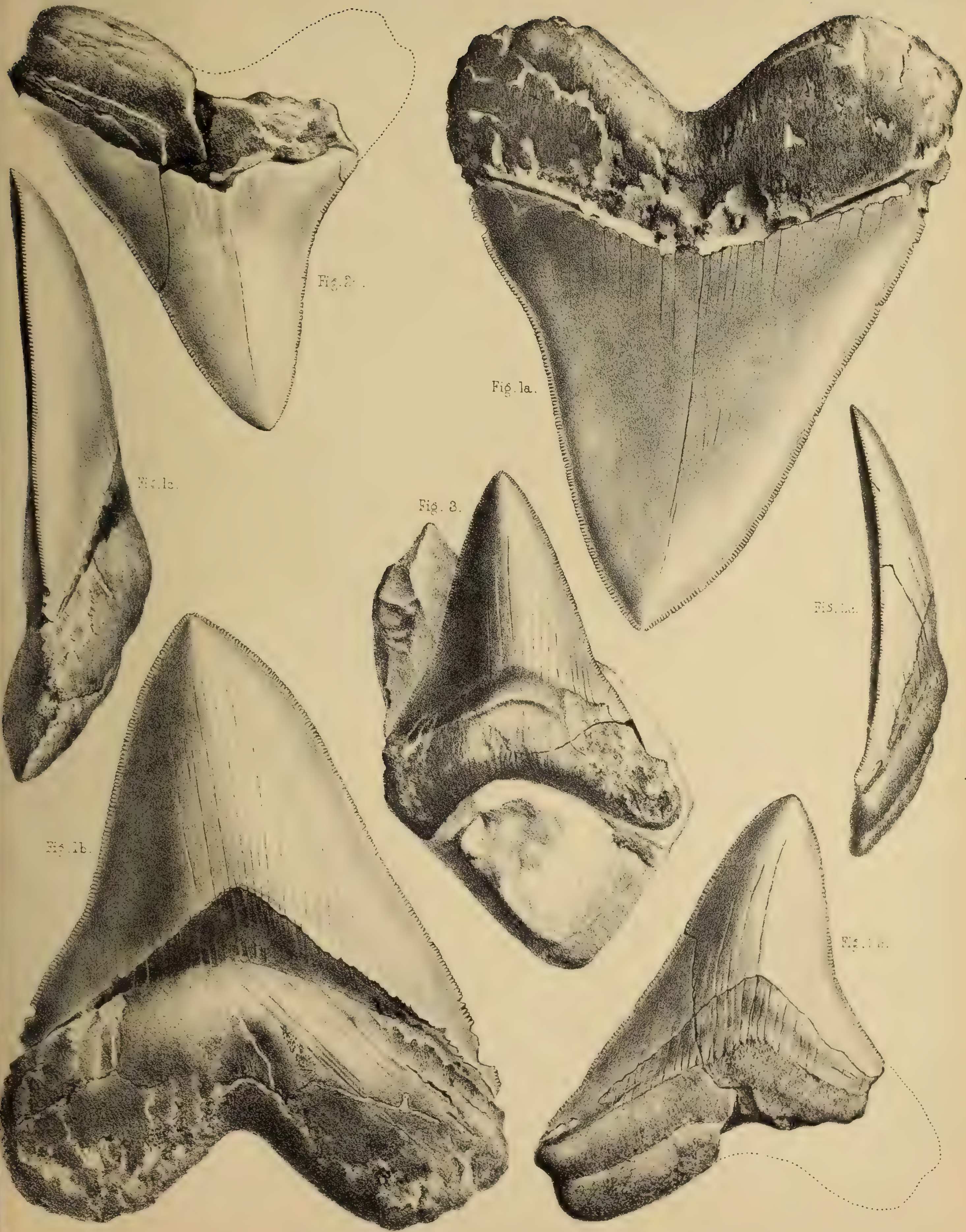
Fig. 2, Carcharodon megalodon. Agassiz.

a. External surface. *b*. Internal surface. *c*. Side view.

Wekapass, . . . *Ex coll.* Canterbury Museum, Christchurch.

Fig. 3, Carcharodon megalodon. Agassiz.

Near Bobby's Creek, . . *Ex coll.* Geological Survey Collections Wellington Museum.



J. W. Davis direxit. W. H. Crowther del.

Mintern Bros. imp.

PLATE III.

Fig. 1, . . LAMNA HUTTONI. Davis.
a. External surface. *b.* Internal surface. *c.* Side view.
Cave Valley, Oamara, . . . *Ex coll.* Professor F. W. Hutton.

Figs. 2–5, . LAMNA INCURVA. Davis.
2*a.* External surface. 2*b.* Internal surface. 2*c.* Side view.
2. Kaikoura. 3. Coleridge Gully. 4. Curiosity Shop Beds.
Ex coll. Canterbury Museum, Christchurch.

Figs. 6, 7, . LAMNA ENSICULATA. Davis.
6. External surface.
7*a.* Internal surface. 7*b.* External surface. 7*c.* Side view.
Oamaru, ... *Ex coll.* Canterbury Museum, Christchurch.

Figs. 8–10, . LAMNA MARGINALIS. Davis.
a. External surface. *b.* Internal surface. *c.* Side view.
Broken River, ... *Ex coll.* Cambridge Museum, Christchurch.

Fig. 11, . LAMNA ATTENUATA. Davis (× 3 diameters).
a. External surface. *b.* Internal surface. *c.* Side view.
Coleridge Gully, . . . *Ex coll.* Canterbury Museum, Christchurch.

Fig. 12, . LAMNA LANCEOLATA. Davis.
a. External surface. *b.* Internal surface. *c.* Side view. *d.* Under surface.
Castle Hill Station, Canterbury, . . *Ex coll.* J. Davies Enys.

Fig. 13, . LAMNA CARINATA. Davis.
a. External surface. *b.* Internal surface. *c.* Side view.
Kaikoura Peninsula, . . . *Ex coll.* H. J. Ingles, Otago Museum.

Figs. 14, 15, LAMNA SP.? Vertebræ.
Awamoke and Kaikoura, . *Ex coll.* R. Gillies; T. J. Parker, Otago Museum.

Fig. 16, . LAMNA HECTORI. Davis.
West Wing Amuri Bluff, . *Ex coll.* Sir J. Hector, Geological Survey Collections

Fig. 1.

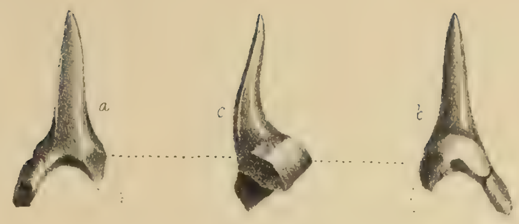


Fig 2

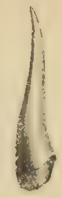


Fig 3

Fig 4

Fig. 8.

Fig. 6.

Fig 5

Fig 9

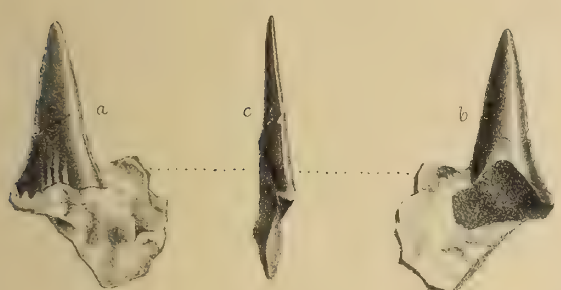


Fig 10

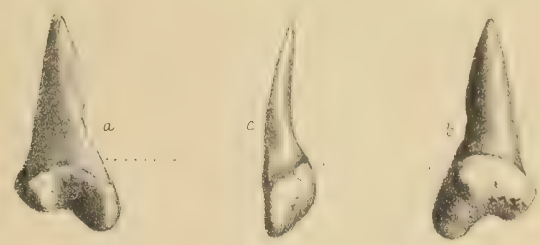


Fig. 7.

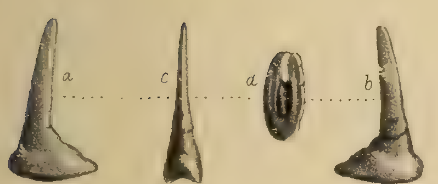


Fig 12

Fig 15

Fig. 13

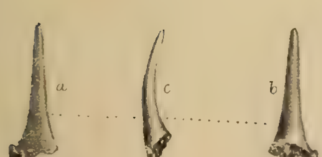


Fig. 11. x 3.

Fig 16.

Fig 14.

EXPLANATION OF PLATE IV.

PLATE IV.

Figs. 1-3, Oxyrhina von haastii. Davis.

1. Mass of detached teeth, probably belonging to one fish.
2. Detached tooth. *a.* Internal surface. *b.* External surface. *c.* Side view.
3. Another specimen.

1 and 2. Oamaru, . . *Ex coll.* Cambridge Museum, Christchurch.

3. Bobby's Creek, . . *Ex coll.* Geological Survey Collections, Wellington Museum

J W Davis direxit W H Crowther del.

Mintern Bros. imp.

EXPLANATION OF PLATE V.

PLATE V.

Figs. 1, 2, . ODONTASPIS ACUTA. Davis.

a. External surface. *b*. Internal surface. *c*. Side view.

1. Curiosity Shop Beds. . . . *Ex coll.* Canterbury Museum, Christchurch.

2. Trelissic, near Canterbury, . . *Ex coll.* Wellington Museum.

Figs. 3, 4, 5, ODONTASPIS EXIGUA. Davis.

3*a*. External surface. 3*b*. Side view. 4. Posterior tooth. 4*a*. Same, enlarged. 5. Anterior tooth. 5*a*. Same, enlarged.

3. Castle Hill Station, near Canterbury, . *Ex coll.* J. Davies Enys.

4, 5. Broken River, . . . *Ex coll.* Canterbury Museum.

Figs. 6–10, .. ODONTASPIS KAIKORAENSIS. Davis.

6*a*. Internal surface. 6*b*. Side view. 7, 8, 9. External surface of other specimens. 10. Similar to 6, with much shorter root.

6. Kaikoura, ... *Ex coll.* J. Davies Enys.

7–10. Eastwing, Amuri Bluff, . *Ex coll.* Wellington Museum.

Figs. 11–13, ODONTASPIS SULCATA. Davis.

11*a*. Enlarged. 13. Surface smoothed by abrasion.

All from Amuri Bluff, . . . *Ex coll.* Wellington Museum.

Fig. 14, . . OXYRHINA RECTA. Davis.

a. External surface. *b*. Internal surface. *c*. Side view.

Castle Hill Station, near Canterbury, . *Ex coll.* J. Davies Enys.

Figs. 15, 16, OXYRHINA GRANDIS. Davis.

a. External surface. *b*. Internal surface. *c*. Side view.

Broken River, ... *Ex coll.* Canterbury Museum, Christchurch.

Figs. 17–20, OXYRHINA ENYSII. Davis.

a. External surface. *b*. Internal surface. *c*. Side view.

Waipara, ... *Ex coll.* Canterbury Museum, Christchurch.

Fig. 21, . OXYRHINA ACUMINATA. Davis.

a. External surface. *b*. Internal surface. *c*. Side view.

Castle Hill Station, near Canterbury, . *Ex coll.* J. Davies Enys.

Plate V.

J W Davis, direxit. W H Crowther, del.

Mintern Bros. imp.

[illegible]

EXPLANATION OF PLATE VI.

PLATE VI.

Figs. 1–3, . Oxyrhina fastigiata. Davis.
1*a*. External surface. 1*b*. Internal surface. 1*c*. Side view.
2. Anterior tooth. 3. Posterior tooth.
Coleridge Gully, ... *Ex coll.* Canterbury Museum, Christchurch.

Fig. 4, . . Oxyrhina subvexa. Davis.
a. External surface. *b*. Internal surface. *c*. Side view.
Oamaru, ... *Ex coll.* J. Davies Enys.

Fig. 5, . . Oxyrhina lata. Davis.
Kakahu River, South Canterbury, . *Ex coll.* Professor T. J. Parker, Otago.

Fig. 6, . . Notidanus primigenius. Agass. (Upper jaw).
Cave Valley, Oamaru, . . . *Ex coll.* Professor F. W. Hutton, Otago.

Figs. 7, 8, . Notidanus marginalis. Davis.
7. (Upper jaw). *a*. External surface. *b*. Internal surface. *c*. Side view.
8. (Lower jaw). *a*. External surface. *b*. Internal surface. *c*. Side view.
Castle Hill Station, . . . *Ex coll.* J. Davies Enys.

Figs. 9–12, . Notidanus dentatus. A. Smith-Woodward.
9. Tooth from upper jaw. 10. Tooth from lower jaw.
Amuri Bluff, . . *Ex coll.* Natural History Department, British Museum.
11 and 12. Teeth, lower jaw.
Amuri Bluff, Waireka series. *Ex coll.* Geological Survey Collection, Wellington.

Figs. 13–15, Trigon ensifer. Davis.
13. Teeth. *a*. Median tooth, enlarged. *b*. Lateral tooth, enlarged.
Coleridge Gully, ... *Ex coll.* Canterbury Museum, Christchurch.
14. Spine, 14*a*. Same, enlarged.
Waipara, ... *Ex coll.* Canterbury Museum, Christchurch.
15. Spine, another example. 15*a*. Enlarged.
Amuri Limestone, Amuri Bluff. . *Ex coll.* Geological Survey Collections, Wellington.

Figs. 16–19, Myliobatis plicatilis. Davis.
a. Upper surface. *b*. Under surface. *c*. Side view.
16, 17, Castle Hill Station, . . *Ex coll.* J. Davies Enys.
18, 19, ... *Ex coll.* Canterbury Museum, Christchurch.

Figs. 20, 21. Myliobatis arcuatus. Davis.
a. Upper surface. *b*. Under surface. *c*. Side view.
20, ... *Ex coll.* Canterbury Museum, Christchurch.
21. Castle Hill Station, . . . *Ex coll.* J. Davies Enys.

Fig. 22, . Carcharodon angustidens. Agass. (young example).
Napier Series, Esk River, Hawkes' Bay, . *Ex coll.* Sir James Hector, M.D., Geological Survey Collections.

W Davis direxit W H Crowther del.

Mintern Bros imp.

EXPLANATION OF PLATE VII.

PLATE VII.

Figs. 1, 2, . Myliobatis altus. Davis.
1a. Upper surface. *b.* Under surface. *c.* Side view.
2. Median part of another tooth.
Broken River, . . *Ex coll.* Canterbury Museum, Christchurch.

Figs. 3–7, . Sargus laticonus. Davis.
Coleridge Gully, . . *Ex coll.* Canterbury Museum, Christchurch.

Fig. 8, . Otoliths ? Sargus.
a. Upper surface. *b.* Lower surface. *c.* Side view.
Coleridge Gully, . . *Ex coll.* Canterbury Museum, Christchurch.

Fig. 9, . Squalodon serratus. Davis.
Whiterock River Quarry, . *Ex coll.* Canterbury Museum, Christchurch.

Fig. 10, . Ischyodus brevirostris. Agassiz.
Right mandible.
Amuri Bluff, . . . *Ex coll.* Natural History Department, British Museum.

Figs. 11–13, Ischyodus brevirostris. Agassiz.
11 and 12. Under surface of a jaw.
13. Upper surface of a jaw.
Amuri Bluff, . . . *Ex coll.* Geological Survey Collections, Wellington.

Fig. 14, . Callorhynchus hectori. Smith-Woodward.
Amuri Bluff, . . . *Ex coll.* Natural History Department, British Museum.

Fig. 15, . Callorhynchus hectori. Smith-Woodward.
a. Upper surface. *b.* Under surface of jaw.
Eastwing Amuri Bluff, . *Ex coll.* Geological Survey Collections, Wellington.

Fig. 16, . Otodus obliquus. Agassiz.
Amuri Bluff, . . . *Ex coll.* Geological Survey Collections, Wellington.

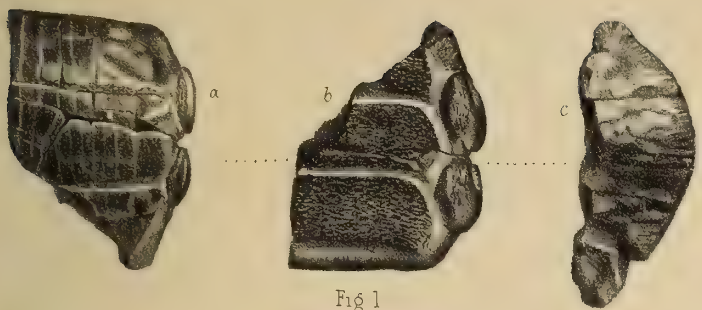


Fig 1

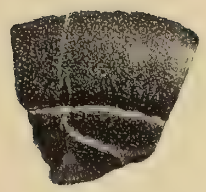


Fig 2.

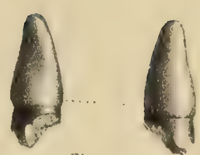


Fig. 3.

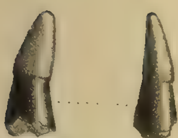


Fig. 4.

Fig 5

Fig. 6

Fig 7

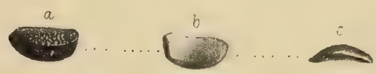


Fig 8

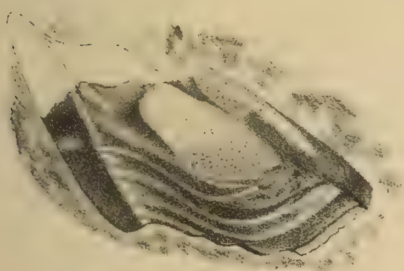
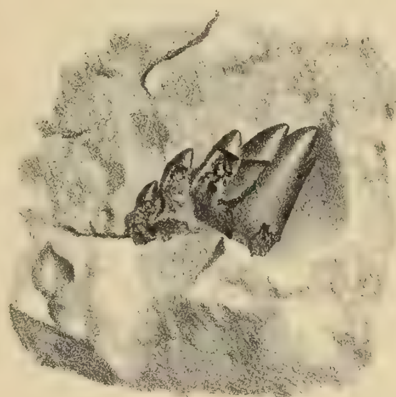


Fig. 10

Fig. 14



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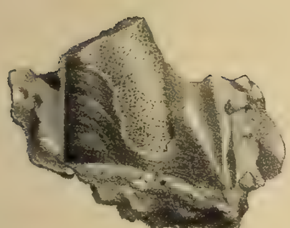


Fig. 13.

Fig 12

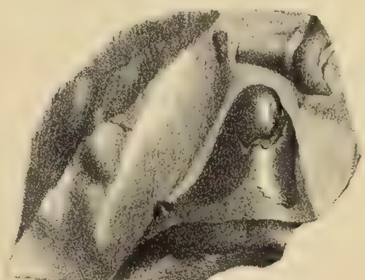


Fig. 16.

Fig. 11.

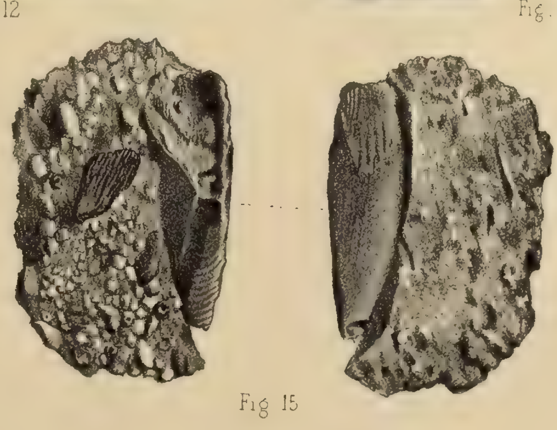


Fig 15

J W Davis direxit W H Crowther del.

Mintern Bros imp.

II.

A MONOGRAPH OF THE MARINE AND FRESHWATER OSTRACODA OF THE NORTH ATLANTIC AND OF NORTH-WESTERN EUROPE. SECTION I. PODOCOPA. BY GEORGE STEWARDSON BRADY, M. D., F.R.S., F.L.S., AND THE REV. ALFRED M. NORMAN, M.A., D.C.L., F.L.S. PLATES VIII. TO XXIII.

(Communicated by PROFESSOR HADDON.)

[Read MARCH, 1888.]

WE propose to include in this memoir all the species of Podocopa known to us as inhabiting the Arctic Seas, the North Atlantic Ocean, and North-Western Europe. We have regarded the North Atlantic as terminating at 35° N., thus excluding the tropical species of the West Indies and Gulf of Mexico. The Mediterranean is not included, as a consideration of all the forms belonging to that area would have too greatly extended our work. In North-Western Europe we embrace Scandinavia, Denmark, Holland, Belgium, Germany, Austria, France, and the British Islands.

The marine species of Norway have been studied by Professor G. O. Sars and Dr. Norman; those of Sweden by Professor Lilljeborg. Little has been done with respect to the marine species of Denmark and Germany since the time of O. F. Müller, except that a few species have been carefully investigated by Dr. Zenker and Dr. Wilh. Müller. Our knowledge of Dutch marine Ostracoda has been derived from the examination by Dr. Brady of material dredged by Mr. E. C. Davison in the rivers Maas and Scheldt. The Ostracoda of the coasts of Belgium and France have not been studied, except that a large number of interesting forms have rewarded the investigations of the Marquis de Folin, and Dr. Norman in the Fosse de Cap Breton in the Bay of Biscay. The expeditions of the British Government, in H. M. SS. *Porcupine*, *Lightning*, and *Triton*, have afforded valuable material with respect to the Ostracodan fauna of the depths of the Atlantic. With the exception of Greenlandic forms, which are known to us from mud and sand procured from whalers, from the dredgings of Dr. Sutherland, and from the expedition of the

Alert, *Discovery*, and *Valorous*, little is known of truly Arctic species. The Ostracoda of the American side of the Atlantic have not been studied, and our endeavours to procure material from that portion of the area have hitherto failed. A few species from the Gulf of St. Lawrence were described, some years ago, by Dr. Brady, but nothing whatever is known of the species which inhabit the coasts of the United States.

The freshwater Ostracoda have been more or less studied in Norway by G. O. Sars; in Sweden by Lilljeborg; in Denmark by no one since the time of O. F. Müller; in Holland not at all; in Belgium by Plateau; in Germany by Koch, Zaddach, and Wilh. Müller; and a few species have also been kindly forwarded to us by Herr Poppe; in England by Baird, our old friend Mr. D. Robertson, Mr. Scott, and ourselves. At the time when the MS. of this paper was sent to the printer we knew absolutely nothing of the inland Ostracoda of France; but these are now being worked at by Professor R. Moniez, of Lille, who has published two or three short but interesting Papers upon them.

The distribution of living species, as far as known, is briefly recorded, whether within or beyond the district with which we are more immediately concerned; and the same method has been adopted with respect to species occurring in post-tertiary deposits.

The present memoir, though embracing a larger area, is intended to supplement the account of the British species given in "A Monograph of the recent British Ostracoda," published by Professor G. S. Brady in the Transactions of the Linnean Society (vol. xxvi., 1868). The species referred to in that work are therefore not here re-described or figured, except in the few cases where it was considered that the illustrations in the "Monograph" were scarcely sufficient to distinguish the species from more recently discovered forms.

For the same reason the synonymic references given in that "Monograph" will not be found here, though we have thought it convenient briefly to mention such synonyms; so that in these pages the full synonymy may be found, without an undue repetition of references. A list of the principal Works and Papers on the Ostracoda of the area embraced in this memoir is given at the end.

Without the kindly co-operation of many others, this work must have been far less complete than we have now been able to make it.

Mr. D. Robertson has most kindly placed his very extensive collection of Ostracoda, including some undescribed forms, at our disposal; and we are indebted to Mr. T. Scott and the late Dr. Malcolmson for the communication of new or interesting forms.

To our ever kind friend, Professor G. O. Sars, of Christiania, we are greatly indebted for much valuable help. Not only has he supplied us with specimens of many Norwegian species described by himself and otherwise unattainable, but,

when unable to send specimens, has most liberally given us outline drawings for reproduction in our illustrations.

Professor Seeliger of Königsberg has rendered valuable assistance to the cause of science in generously entrusting to our care the types of Zaddach's species preserved in the Museum of that town, and thus synonymy has been rectified in a way which could not otherwise have been done.

Our sincere thanks for the communication of specimens and information are also due to Professor Lilljeborg of Upsala, Dr. Wilhelm Müller of Greifswald, Herr Poppe of Vegesack, Professor Moniez of Lille, Professor Orley of Budapest, and Professor Heller of Innsbrück.

Lastly, we owe much to the kindness of our friend, the Marquis de Folin, who has not only placed at our disposal many Ostracoda dredged by himself in his important investigations in the Fosse de Cap Breton, but also some highly interesting Myodocopa procured from great depths by the French expeditions of the *Travailleur* and *Talisman*.

The mark (!) after a locality indicates that we have identified specimens from that place, or the types of the author after whose name it is placed.

OSTRACODA.

Section I.—Podocopa.

Fam. I.—CYPRIDIDÆ.

Shell generally thin and horny; valves equal or but slightly unequal in size, surface usually smooth, or simply punctated; ventral margins more or less sinuated; hinge margins edentulous. Eyes simple, usually confluent, sometimes wanting. Antennules (first antennæ) slender, usually seven-jointed, very flexile, usually provided with a number of long hairs forming a dense brush. Antennæ (second antennæ) pediform, geniculated, four- or five-jointed, clawed at the apex, second joint mostly bearing an apical brush of hairs. Mandibles strong, apex strongly toothed, palp four-jointed, with a setiferous branchial plate at the base. Two pairs of maxillæ, the first pair four-digitate; its external branch distinctly two-jointed, bearing a large setiferous branchial plate; second pair small, composed of a single prehensile lobe and a palp, which in the female is

generally simple, rarely pediform, is in the male prehensile. Two pairs of feet dissimilar in structure, the anterior pair strong, ambulatory, directed downwards, and having a long curved apical claw; posterior bent backwards within the shell, and not used for motion. Caudal rami usually well developed, elongated, very mobile, and bearing two or three apical claws. Intestine forming two dilatations, of which the anterior is provided with cœcal appendages. Generative organs large, and of complex structure, and partly extended within the valves; in the male frequently a complex whorled sac (? ejaculatory organ) connected with the testis; copulatory organs symmetrical, and of moderate size.

Fam. II.—BAIRDIIDÆ.

Shell generally hard and calcareous, valves unequal, surface smooth, hinge toothless. No eyes. Antennules scarcely geniculated, seven-jointed; first two joints elongated, the rest very short, but beset with long hairs. Antennæ pediform, five-jointed, clawed, but destitute of a setose brush. Mandibles large; biting extremity incurved, and strongly toothed; palp well developed; branchial appendage small, and bearing only a few non-ciliated setæ. First pair of maxillæ only adapted for mastication; second pair, as well as the two following pairs of appendages, ambulatory, pediform, and directed downwards. Two pairs of branchial plates, one attached to the first, the other to the second pair of maxillæ. Caudal rami well developed, though not large; linear, clawed. Ovaria and testes not extended within the valves; whorled sac wanting. Copulative organs of the male moderately large and complex. Animal not adapted for swimming.

We follow Professor G. O. Sars in dividing the old group, Cyprididæ, into two families, Cyprididæ and Bairdiidæ, the chief points of distinction being found in the structure of the second and fourth pair of "post-oral appendages" (second maxillæ and second pair of feet); also in the absence of a whorled sac in the males of the Bairdiidæ, and in their very unequally-valved shell.

Fam. III.—DARWINULIDÆ.

Antennæ destitute of swimming setæ and of poison gland and duct. Mandible-palp three-jointed; the basal joint large and densely setiferous. Two pairs of jaws, the first bearing a large branchial plate, the second a smaller branchial plate and a pediform palp. Two pairs of feet external to the valves. Post-abdominal lobes sub-conical, small.

Fam. IV.—CYTHERIDÆ.

"Shell mostly hard, calcareous, usually with an uneven surface, either sparingly clothed with hairs or altogether bare; hinge generally toothed. Eyes more or less separated, sometimes wanting. Antennules sub-pediform, geniculate at the base; five- to seven-jointed; beset with short setæ, which are partly spine-like. Antennæ strong, pediform, curved, four- or five-jointed, with two terminal claws; basal joint bearing a long setiform, biarticulate flagellum, which conveys a duct from a poison-gland; second joint destitute of a setose brush. Mandibles usually strong, enlarged and toothed at the apex; palp well developed, directed forwards, and bearing on the posterior margin strong, curved setæ, and a poorly-developed branchial appendage. First pair of post-oral appendages more or less maxilliform; three following alike, pediform, directed downwards, adapted for walking. One pair of branchial laminæ attached to the maxillæ. Caudal rami obsolete, forming two rounded, setiferous lobes; copulatory organs of the male large and complex: in addition to which there is a curious bifurcate appendage between the feet of the first pair; ovaria and testes not produced between the valves; no mucous gland. Animal incapable of swimming." (G. O. Sars.)

Fam. V.—PARADOXOSTOMATIDÆ.

Shell thin and fragile, smooth; contact margins imperfectly closed in front, allowing of the protrusion of the mandibles. Poison glands large; noticating setæ large and stout. Mandibles slender and styliform, adapted for piercing, enclosed in a suctorial sheath formed by the coalesced labrum and labium; palp without a branchial appendage. First pair of maxillæ bearing a branchial plate, which is provided with two setæ.

Fam. I.—CYPRIDIDÆ.

Genus I. — Cypria, Zenker.

Limbs longer and more slender than in Cypris; swimming setæ of the antennæ few (usually five) in number, and of great length. Apical joint of the mandible-palp very long and slender. Principal apical seta of the second foot very long—about as long as the entire limb. In the male the second pair of jaws is prehensile and somewhat different on the two sides (right and left); the whorled sac is cylindrical, and bears seven whorls of filaments, the two terminal whorls chitinous, rigid, and composed of few (seventeen); the other five of very numerous and fine filaments; the upper extremity of the organ forms a dilated blind pouch, the lower (distal) extremity forming a funnel-shaped sac, which leads into the *vas deferens;* copulative organs of moderate size. Zoosperms longer and more slender than in Cypris; arranged in two compact coils over the back of the animal. Eyes large, not widely separated, united at the base; ovarian tubes of female having a double curve.

[*Type.—Cypria exsculpta* (Fischer) = *C. punctata, var. striata*, Zenker.]

The species of Cypria are all small, and ovate or reniform in outline. They form two groups, one containing *C. exsculpta* and *C. ophthalmica*, in which the valves are sub-compressed, the other embracing the remaining forms, which are all very tumid.

1. *Cypria exsculpta* (S. Fischer).

(Plate xi., figs. 1–4.)

1853. *Cypris elegantula*, Lilljeborg, De Crust. ex ord. tribus, p. 206 (*non C. elegantula*, Fischer).
1854. *Cypris exsculpta*, Fischer, Beitrag zur Kenntniss der Ostracoden, p. 18, pl. xix., figs. 36–38.
1854. *Cypria punctata, var. striata*, Zenker, Monog. der Ostracoden, Archiv für Naturgeschichte, p. 77, pl. iii., figs. 1–6.
1868. *Cypris striolata*, Brady, Mon. rec. Brit. Ostrac., p. 372, pl. xxiv., figs. 6–10.
1880. *Cypris granulata*, Robertson, Fresh and Brackish Water Ostracoda of Clydesdale, p. 18 (junior.)

Additional localities.—This is a widely-distributed species, and has been met with in many localities in the East Anglian district (G. S. B. & D. R.): Osmere, near Whitchurch, Shropshire (G. S. B.): at Lochmaben; Cumbrae; Upper Braide, Farne Loch, Edinburgh; Possil Marsh, Glasgow; and canal at Peterhead; in lochs near Dumfries, and in the Isle of Lewis (D. R.); at Hairmyres, near East Kilbride;

in moor tarns at Glenluce, and in Whitefield Loch, Wigtonshire; Loch Aber, Kircudbrightshire; Newbiggin, Northumberland; Seaton Carew, Co. Durham; and Kibworth, Leicestershire (A. M. N.)

Distribution.—Sweden (Lilljeborg!); Prussia (Zenker); Russia (S. Fischer); France (Moniez).

2. *Cypria ophthalmica* (Jurine).

(Plate xi., figs. 5–9.)

1820. *Monoculus ophthalmicus*, Jurine, Hist. des Monocles, p. 178, pl. xix., figs. 16, 17.
1838. (?) *Cypris punctata*, Koch, Deutschl. Crustac., H. 21, p. 23, fig. 23 (*non C. punctata*, Jurine).
1837. *Cypris tenera*, idem, ibidem, H. 12, p. 3.
1835. *Cypris compressa*, Baird, Trans. Berw. Nat. Club, vol. i., p. 100, pl. iii., fig. 16.
1851. *Cypris elegantula*, Fischer, Ueber das Genus Cypris, p. 161, pl. x., figs. 12, 13.
1868. *Cypris compressa*, Brady, Mon. rec. Brit. Ostrac., p. 372, pl. xxiv., figs. 1–5; pl. xxxvi., fig. 6.
1872. *Cypris ovum*, Fric, Die Krustenthiere Böhmens, p. 228.
1875. *Cypris compressa*, Brady, Crosskey, and Robertson, Post-tert. Entom., p. 123, pl. i., figs. 5, 6.

One of the commonest of British species, occurring everywhere in ditches, ponds, and lakes, both freshwater and brackish.

Distribution.—Norway (G. O. Sars); Sweden (Lilljeborg!); Belgium (Plateau); Germany (Koch and Wilh. Müller); Geneva (Jurine); Russia (S. Fischer); Bohemia (Fric); France (Moniez), also recorded by him as *C. joanna;* Transylvania (Daday).

Fossil.—England, Scotland.

3. *Cypria lævis* (O. F. Müller).

1785. *Cypris lævis*, Müller, Entom., p. 52, pl. iii., figs. 7–9.
1820. *Monoculus ovum*, Jurine, Hist. des Monocles, p. 179, pl. xix., figs. 18, 19.
1835. *Cypris minuta*, Baird, Trans. Berw. Nat. Club, i., p. 99, pl. iii., fig. 9; and Brit. Entom., p. 155, pl. xviii., figs. 7, 8.
1837. *Cypris brunnea and lepidula*, Koch, Deutschlands Crustaceen, H. x., 5 and 6.
1844. *Cypris vulgaris*, Zaddach, Syn. Crust. Pruss. Prod., p. 35.
1851. *Cypris pantherina*, Fischer, Abhandl. über das Genus Cypris, p. 163, pl. xi., figs. 6–8.
1853. *Cypris ovum*, Lilljeborg, De Crust. ex ord. tribus, p. 113, pl. x., figs. 13–15.
1868. *Cypris ovum*, Brady, Mon. rec. Brit. Ostrac., p. 373, pl. xxiv., figs. 31–34, 43–45; and pl. xxxvi., fig. 8.
1868. *Cypris ovum*, Claus, Beiträge zur Kenntniss der Ostracoden, Entwicklungsgeschichte von Cypris, pl. i., figs. 1-5.
1874. *Cypris ovum*, Brady, Crosskey, and Robertson, Post-tert. Entom., p. 125, pl. i., figs. 29–31.

Common in Great Britain and Ireland, in fresh and brackish water.

Distribution.—Norway (Sars); Sweden (Lilljeborg !); North Germany ! (Poppe); Denmark (Müller); Belgium (Plateau); France (Moniez); Prussia (Zaddach !); Switzerland (Jurine); Russia (Fischer); Hungary (Orley); Finland (Cajander); Transylvania (Daday).

Fossil.—England, South Wales (Cardiff); var. ? Sicily (Seguenza).

There is great difficulty in disentangling the synonymy of this and the following species. The colouring of Koch's figures of *C. brunnea* and *C. lepidula* is very characteristic of this species, though the outline, as seen from above, is represented as much too tumid.

4. *Cypria serena* (Koch).

1838. *Cypris serena*, Koch, Deutschlands Crustaceen, H. xxi., 22.
1838. *Cypris fuscata*, Koch, id., ibid., H. xxi., 21.
1844. (?) *Cypris rubida*, Zaddach, Synops. Crust. Prussic. Prod., p. 36.
1851. *Cypris scutigera*, Fischer, Abhandl. über das Genus Cypris, p. 162, pl. xi., figs. 3–5.
1854. *Cypria ovum*, Zenker, Monog. der Ostracoden, p. 79, pl. iii. B.
1868. *Cypris lævis* Brady, Mon. rec. Brit. Ostrac., p. 374, pl. xxiv., figs. 6–8.
1874. *Cypris lævis*, Brady, Crosskey, and Robertson, Post-tert. Entom., p. 126, pl. i., figs. 25–28.
1874. *Cypris ovum*, Heller, Unters. über die Crustaceen Tirols, p. 89.
1880. *Cypris ovum*, Wilh. Müller, Zeitsch. für gesammt. Naturwiss., vol. vi., p. 221, pl. iv., fig. 11.

Common in ditches, slow streams, and lakes.

Distribution.—Norway (Sars); Sweden (Lilljeborg !); Belgium (Plateau); France (Moniez); Prussia (Zaddach); Pomerania (Wilh. Müller !); Tyrol (Heller); Hungary (Orley); North Germany (Poppe !).

Fossil.—Scotland, England.

No specimens of *C. rubida* exist in Zaddach's collection.

5. *Cypria joanna* (Baird).

1868. *Cypris joanna*, Brady, Mon. rec. Brit. Ostrac., p. 375.

This species is unknown to us.

Genus II.—CYCLOCYPRIS, n. g.

(Κύκλος, a circle.)

Like Cypria, except in the structure of the mandible—which has the terminal joint of the palp short—and the whorled sac of the male, the whorls of which are composed of very numerous and excessively fine and long filaments; the extremities of the cylinder are not dilated, nor are they provided with circlets of stout setæ, as in Cypria, nor is there any distinct central axis; the whole organ is enveloped in a capacious capsule.

Cyclocypris globosa (G. O. Sars).

(Plate XIV., figs. 1, 2; Plate XI., figs. 10–18.)

1844. (?) *Cypris incana*, Zaddach, Syn. Crust. Pruss. Prod., p. 33.
1863. *Cypris globosa*, G. O. Sars, Om en i Sommeren 1862 foretagen Zoologisk Reise i Christianias og Trondhjems Stifter, p. 27.
1868. *Cypris cinerea*, Brady, Mon. rec. Brit. Ostrac., p. 374, pl. xxiv., figs. 39–42; pl. xxxvi., fig. 7.
1874. *Cypris cinerea*, Brady, Crosskey, and Robertson, Post-tert. Entom., p. 126, pl. ii., figs. 6, 7.

Shell of the male very tumid; seen laterally, ovate or sub-ovate; highest near the middle; height equal to two-thirds of the length; extremities rounded, the anterior somewhat the narrower of the two; dorsal margin gently arched in the middle, sloping steeply behind, but more gradually towards the front; ventral margin almost straight. Seen from above, the outline is broadly ovate; greatest width equal to the height, and situated behind the middle; broadly rounded behind, abruptly tapered and subacuminate in front. Surface smooth and polished for the most part, but on the ventral margin and at the extremities clothed with numerous short hairs, intermingled with which are a few of excessive length; at the posterior ventral angle is a very dense growth of short hairs. Colour, brown, or yellowish-brown, with darker cloudings. Length, 0·84 mm. The long setæ of the antennæ are only two or three in number. Female unknown.

The specimens from which the description in the "Monograph of recent British Ostracoda" was drawn up were immature, and the description and figures consequently faulty. We have therefore here re-described the species from full-grown examples.

Additional localities.—Isle of Lewis, and Lochmaben (D. R.); ditches by side of Loch Ascog; side of Greenan Loch; and pools above high-water mark, West Loch Tarbert (Mr. T. Scott): Broomley Lough, Northumberland (A.M.N.): ditch near Barlay Loch, Kirkcudbrightshire; and pools at head of Easedale, Westmoreland (G. S. B.) No specimens of *C. incana* exist in Zaddach's collection.

Distribution.—Norway (G. O. Sars).

Fossil.—Scotland (Crofthead).

Genus III.—SCOTTIA, n. g.

Shell not unlike that of the tumid forms of Cypria. Setæ of the antennæ extremely short, not reaching even to the base of the claws. Whorled sac of the male as in Cyprois. Limbs short and stout; claws of the caudal rami very stout, short, and twisted.

Scottia browniana (Jones).

(Plate IX., figs. 23, 24; Plate XI., figs. 19–25.)

1856. *Cypris browniana*, Jones, Mon. Tertiary Entom., p. 13, pl. i., figs. 1, *a-d*.

Shell short, high, and very tumid; seen laterally sub-ovate, highest behind the middle; height equal to more than half the length; anterior extremity obliquely, posterior more evenly rounded and broader; dorsal margin forming a somewhat flattened arch, the hinder slope steeper than that in front; ventral margin only slightly sinuated. Seen from above, broadly ovate, widest in the middle, breadth equal to the height; ends very broadly rounded, and nearly equal; end view almost circular. Surface smooth and polished, with a few scattered minute hairs, which are only with difficulty seen; shell pellucid, irregularly pencilled with dark markings; the brown colour of the animal also visible through the shell. Setose brush of the antenna consisting of only three or four very short, simple hairs; terminal claws armed with a comb-like tuft of short, rigid setæ, extending over the middle of the inner margin for about one-half of its length, and ending abruptly at each extremity. The two claws of each caudal ramus are provided with a similar arrangement; but the tuft is not more than one-fourth of the length of the claw, and the secondary marginal setæ are only very finely pectinated. The second maxilla bears a 6-setose branchial plate, and, in the male, has a strongly-falcate claw. The first pair of feet bear (instead of one) two long falcate ungues at the apex.

Mr. Thomas Scott has recently sent us this species, which he found in pools near Loch Fadd, in the Island of Bute. Its occurrence in a recent state is of great interest, as it has hitherto been known only from Professor Rupert Jones's description of the fossil shell. We have pleasure in naming the genus after Mr. Scott, in acknowledgment of his careful and industrious observations of marine and freshwater invertebrata.

Fossil.—Clacton, in Essex (T. R. Jones).

Genus IV.—Cypris, Müller.

[Type, *C. pubera*, Müller.]

1. *Cypris fuscata*, Jurine.

(Plate xii., figs. 3, 4.)

Synonyms: *C. hispida*, Baird; *C. oblonga*, Brady; *C. fusca*, Baird, *et auct. plur.*

1820. *Cypris fuscata*, Jurine, Hist. des Monocles de Genève, p. 174, pl. xix., figs. 1, 2.
1821. (?) *Cypris fusca*, Straus Durckheim, Mém. des Mus. d'Hist. Nat., vii., p. 59, pl. i., figs. 1–16.
1837. (?) *Cypris adusta* Koch, Deutschlands Crustaceen, H. ii. 3.
1838. *Cypris galbinea*, Koch, Deutschlands Crustaceen, H. xxi. 19 (junior).
1844. *Cypris fuscata*, Zaddach, Synopsis Crust. Prussicorum Prodromus, p. 32.
1853. *Cypris fuscata*, Lilljeborg, De Crust. ex ord. trib. Clad. Ostrac. et Coped, p. 114, pl. x., figs. 6–9; pl. xii., fig. 5.
1868. *Cypris fusca*, Brady, Mon. rec. Brit. Ostrac., p. 362, pl. xxiii., figs. 10–15.

One of the most abundant British species.

Distribution.—Norway (G. O. Sars); Sweden (Lilljeborg!); Denmark (? Müller); Belgium (Plateau); Prussia (Zaddach!); Pomerania (Wilh. Müller!); Geneva (Jurine); Tyrol (Heller); Bohemia (A. Fric); Hungary (Orley); Russia (S. Fischer); Normandy (Moniez); Italy (Saccardo); Transylvania (Daday).

It is remarkable that, as far as we are aware, this common species has not yet been found in a fossil state.

We think that there can be no doubt that Koch's *C. galbinea* represents the young of this species. Types of Dr. Baird's *Candona hispida* are in Dr. Norman's collection.

2. *Cypris incongruens*, Ramdohr.

(Plate xii., figs. 8, 9.)

Synonyms: *M. ruber et aurantius*, Jurine, *et auct.*

1844. *Cypris aurantia*, Zaddach, Syn. Crust. Pruss. Prod., p. 37.
1844. (?) *Cypris ophthalma*, Koch, Deutschlands Crustaceen, &c., H. 36, p. 17 (junior).
1855. *Cypris aurantia*, S. Fischer, Beitrag zur Kenntniss der Ostracoden, p. 650, pl. i., figs. 29–31, 60, 61.
1868. *Cypris incongruens*, Brady, Mon. rec. Brit. Ostrac., p. 362, pl. xxiii., figs. 16–22.

Additional localities.—Seaton Delaval, Northumberland; Rainton and Seaton-Carew, Co. Durham; Weston-on-the-Green, Oxfordshire (A. M. N.), near Staithes, Yorkshire (G.S.B.)

Apparently generally distributed through the British Islands, but most commonly in slightly brackish water: in such situations it often occurs abundantly and of large growth.

Distribution.—Norway (G. O. Sars); Sweden (Lilljeborg!); Belgium (Plateau); France (Moniez); Prussia (Zaddach!); Pomerania (Wilh. Müller!); Geneva (Jurine); Hungary (Orley); Bavaria, Sicily, Russia, Madeira, and Egypt (S. Fischer); Botanical Gardens, Palermo (A. M. N.); Finland (Cajander); Transylvania (Daday).

Lilljeborg is of opinion that the present species is the *C. fusca* of Straus-Durckheim. It is true that the figure more closely resembles the outline of *C. incongruens*, but the description and name *fusca* more closely apply to *C. fuscata*, Jurine, under which species we have referred to it as a doubtful synonym.

3. *Cypris pubera*, O. F. Müller.

Synonymn: *C. cuneata*, Baird (junior), and *C. punctillata*, Norman.

1785. *Cypris pubera*, O. F. Müller, Entomostraca, p. 56, pl. v., figs. 1–5.
1820. *Monoculus ovatus*, Jurine, Hist. des Monocles, p. 170, pl. xvii., figs. 5, 6 (junior).
1844. *Cypris pubera*, Zaddach, Syn. Crust. Prussic. Prod., p. 34.
1844. *Cypris striata*, Zaddach, Syn. Crust. Pruss. Prod., p. 32 (junior).
1851. *Cypris pubera*, S. Fischer, Ueber das Genus Cypris, p. 154, pl. viii., figs. 1–8.
1853. *Cypris pubera*, Lilljeborg, De Crust. ex ord. tribus, p. 109, pl. x., figs. 1–5.
1868. *Cypris punctillata*, Brady, Mon. rec. Brit. Ostrac., p. 365, pl. xxvi., figs. 1–7; pl. xxxvi., fig. 11.
1868. *Cypris pubera*, Heller, Unters. über die Crustaceen Tirols, p. 83.

Additional localities.—Town Hill Loch, Dunfermline (D. R.): Hemsworth Dam, Yorkshire; freshwater pond on Seaton Marsh, Co. Durham (G. S. B.). The British Museum collection contains specimens from Highgate Ponds, marked *C. tristriata.*

Distribution.—Norway (G. O. Sars); Sweden (Lilljeborg!); Denmark (O. F. Müller); Belgium (Plateau); France (Moniez); Prussia (Zaddach!); Pomerania (Wilh. Müller, *in litt.*); Geneva (Jurine); Tyrol (Heller!); Hungary (Orley); Russia (S. Fischer); Finland (Cajander); France (Moniez!); Italy (Saccardo); Transylvania (Daday).

4. *Cypris virens* (Jurine).

Synonym: *C. tristriata*, Baird.

1838. *Cypris gibberala*, Koch, Deutschlands Crustaceen, &c., H. xxi., 20 (junior).
1844. *Cypris virens*, Zaddach, Syn. Crust. Pruss. Prod., p. 35.
1844. *Cypris pilosa*, Zaddach, Syn. Crust. Pruss. Prod., p. 36 (= *var. ventricosa*, B. and R.)
1851. *Cypris ornata*, Fischer, Ueber das Genus Cypris, p. 157, pl. ix., figs. 7–10.
1868. *Cypris virens*, Brady, Mon. rec. Brit. Ostrac., p. 364, pl. xxiii., figs. 23–32; pl. xxxvi., fig. 1.
1870. *Cypris ventricosa*, Brady and Robertson, Ann. Nat. Hist., ser. 4, vol. vi., p. 12, pl. iv., figs. 1–3.
1872. *Cypris pubera*, Fric, Die Krustenthiere Böhmens, p. 226.
1875. *Cypris virens*, Brady, Crosskey, and Robertson, Post-tert. Entom., p. 124, pl. ii., figs. 27, 28.
1887. *Cypris Helena*, Moniez, Note sur des Ost. Clad. et Hydrachnides observes en Normandie (Bull. Soc. d'études scient. de Paris), separate copy, p. 2.

Distribution.—Norway (G. O. Sars); Sweden (Lilljeborg!); Belgium (Plateau); Prussia (Zaddach); Pomerania (Wilh. Müller, *in litt.*); Geneva (Jurine); Bohemia (Fric); Hungary (Orley!); France (Moniez); Transylvania (Daday).

Fossil.—Scotland.

One of the commonest and most widely distributed of British freshwater species.

It is an inhabitant of grassy pools and ditches which dry up in the summer. We do not remember to have ever found it in a large sheet of water.

Koch has not apparently met with the adult form, but there can be little doubt that his *C. gibberula* is the young state of *C. virens.*

A large variety, with the row of bead-like tubercles on the anterior margin largely developed, is var. *monilifera* of Brady. This was found by Mr. T. Scott in pools near Loch Ascog, in Bute, and near Paisley; it occurs also in gatherings from the English Fen district, and may be looked upon as a sub-brackish variety.

A still more interesting variety is the *C. ventricosa* (B. and R.), which has recently been re-described from Normandy, as *C. helena*, by Prof. Moniez, to whose kindness we are indebted for specimens. As far as we can judge also from the examination of Zaddach's type specimens of *C. pilosa*, Zaddach (*non* Müller), which are not in good order, it is also the same form. Var. *ventricosa* is more ventricose than the typical *C. virens*, shorter in proportion to the length, and considerably higher, and more broadly rounded at the posterior extremity; but the connexion with the type is shown by the general characters, and especially by the presence, a little within the anterior border, of the row of tubercles, peculiarly characteristic of that species. In clean specimens these tubercles may generally, though not always, be found more or less distinctly developed. An intermediate form has been found by A. M. N. in a pond in Lumley Dene, Co. Durham.

5. *Cypris elliptica*, Baird.

(Plate IX., figs. 5, 6; Plate XII., fig. 12.)

1820. (?) *Cypris unifasciata*, Jurine, Hist. des Monocles, p. 176, pl. xix., figs. 9, 10 (junior).
1846. *Cypris elliptica*, Baird, Trans. Berw. Nat. Club, II., p. 152, 1846; Ann. and Mag. Nat. Hist., XVII., p. 414, pl. ix., fig. 2; Nat. Hist. of Brit. Entom., p. 158, pl. xix., fig. xii.
1850. *Cypris hirsuta*, Fischer, Ueber das Genus Cypris, p. 159, pl. x., figs. 6-8.

Shell seen from the side, sub-ovate, inclining to sub-triangular, highest near the middle; height equal to more than half the length; anterior extremity broadly and evenly rounded, posterior narrowed and rounded; dorsal margin boldly arched, highest in the middle, sloping with a gentle curve to the front, and more steeply

backwards; ventral margin slightly sinuated in the middle. Seen from above, ovate twice as long as broad, widest in the middle, anterior extremity tapered and acuminate, posterior rather broadly rounded. Surface smooth, beset with a few fine, long hairs. Colour greenish, marked irregularly with darker blotches. Length, 1·3 mm.

Found in a pond in Foxton Lane, Sedgefield, Co. Durham (A. M. N.); pond at Highgate, July, 1846 (Baird!); pond at Stocksfield, Northumberland, Mr. H. B. Watson (G. S. B.)

Distribution.—Sweden (Lilljeborg!); Sergiefskoje, Russia (S. Fischer).

The Foxton Lane specimens are larger than the Swedish ones of Professor Lilljeborg, but do not differ materially in other respects. The hirsute character is absent; but as the specimens had been kept in the dry state and loose in a box for twenty-five years, it is not wonderful that delicate hairs should have disappeared. We have examined Dr. Baird's types, which are in the British Museum Collection, and believe them to be identical with the Swedish specimens of Professor Lilljeborg.

6. *Cypris reticulata*, Zaddach.

(Plate VIII., figs. 1, 2; Plate XI., figs. 5–7.)

1837. *Cypris tricincta*, Koch, Deutschlands Crustaceen, &c., X. 1 (*junior?*).
1844. *Cypris reticulata*, Zaddach, Synops. Crust. Prussic. Prodr., p. 24 (*junior*).
1844. *Cypris insignis*, idem, ibidem, p. 31 (? *partim*).
1851. *Cypris affinis*, Fischer, Ueber das Genus Cypris, p. 32, pl. x., figs. 9–11.
1865. *Cypris tessellata* (in part), Brady, Monog. rec. Brit. Ostrac., p. 336, pl. xxiii., figs. 39–45.
1883. *Cypris affinis*, Lilljeborg, International Fisheries Exhib., London, Sweden Cat., p. 146.

Shell sub-ovate, tumid; seen from the side, sub-reniform; highest in the middle; height equal to half the length; extremities well rounded and nearly equal; superior margin well arched, almost gibbous in the middle; inferior very gently sinuated; seen from above, the outline is regularly ovate, twice as long as broad, the greatest width being in the middle; anterior extremity narrower than the posterior, and acuminated, the left valve being produced to a sharp point. End view nearly circular, except that the ventral margin is produced into a strong keel. Surface of valve smooth, glistening, bearing scattered appressed hairs; colour, pale brownish-green. Length, 1·0 mm.

British localities.—Johnston Loch; Possil Marsh; Bishop Loch; side of Paisley Canal; Mill Loch, Lochmaben; Baron Loch, Peebles (D. R.): Hairmyres, near East Kilbride; and Foxton, near Sedgefield, Co. Durham (A. M. N.): Boldon Flats, near Sunderland; Fenham; and pools north of Seaton Sluice, Northumberland (G. S. B.).

Distribution.—Sweden (Upsala), (Lilljeborg!); Sergiefskoje, near Peterhof, Russia (S. Fischer); Prussia (Zaddach!).

C. affinis comes very near to *C. fusca* and *C. obliqua*, but is more tumid than the former, as well as somewhat different in lateral outline. From the latter it may be known by the valves not being obliquely placed, nor the shell punctated. Moreover, the curious inequality of the two valves, that of the left side being elongated and overlapping in front, gives the species a special peculiarity of its own.

The "tessellated" forms referred in the "Monograph" to *C. tessellata*, Fischer, are really immature examples of one or more species, chiefly of *C. affinis*, Fischer, a species which, in its adult form, has only recently been recognized as British. Tesselation seems to arise from the presence, in the substance of the shell, of symmetrically arranged lacunæ, which become, as age advances, filled up and obliterated by deposit of calcareous matter. Rapidity of growth is probably favourable to the production of the tesselated structure, and may account for its occasional appearance in shells of full size, which, as a rule, possess none of it. In *C. affinis* the tesselation is found in shells of almost full size; and as the shell remains always very thin, it is probable that growth here is unusually rapid. *C. strigata* occurs in little grassy spots, which dry up again very quickly after rain; its great size thus necessitates rapid growth, and remains of tesselation may be seen at times even in the adult. The character of the tesselation varies considerably in different species; but, in one form or another, we have observed it in the young of *C. virens*, *C. pubera*, *C. obliqua*, *C. affinis*, *C. fuscata*, *C. incongruens*, *C. prasina*, *C. crassa*, and *E. strigata*, and these are all the true Cyprides of which we have in our collections the very young stages to examine. *Erpetocypris reptans*, though it inhabits localities similar to those of *E. strigata*, and is probably of equally rapid growth, seems to form an exception to the rule, having in all its stages a perfectly structureless shell. For varieties of tesselation, see Plate xii.

The *C. insignis* of Zaddach is represented in his collection by two forms, one of which is certainly referable to the species now under consideration; the other probably to *C. dromedaria*. But his description, "superficiis marginisque læves," is not correct as applied to the former and tesselated form. Zaddach quotes doubtfully as a synonym, *Monoculus unifasciatus*, Jurine, which species is also recorded by M. Plateau from Belgium, but without description or figure.

7. *Cypris obliqua*, Brady.

(Plate xii., fig. 10.)

1868. *Cypris obliqua*, Brady, Mon. rec. Brit. Ostrac., p. 364, pl. xxiii., figs. 33-38.

Additional localities.—Lewis; Isle of Skye; Bute; Cumbrae; Derwentwater (D. R.): Nostell Lake and Hemsworth Dam, Yorkshire; Blackmere, Shropshire; White Loch, Kirkcudbrightshire; High Cross Tarn, Coniston (G. S. B.): Horsey

Mere and Whittlesea (G. S. B. and D. R.): Crag Lake, Northumberland (A. M. N.)

Apart from difference of shape, the punctate shell of this species helps to distinguish it from the two preceding species.

Distribution.—France (Moniez! recorded by him as *C. unifasciata.*)

8. *Cypris gibbosa*, Baird.

1868. *Cypris gibbosa*, Brady, Mon. rec. Brit. Ostrac., p. 366.

This species is unknown to us. Dr. Baird's description may perhaps be taken to refer either to *Cypris prasina* or *Cyprois flava.*

9. *Cypris prasina*, Fischer.

1850. *Cypris strigata*, Baird, Brit. Entom., p. 157 (*non* Müller).
1855. *Cypris prasina*, Fischer, Beitrag zur Kenntniss der Ostracoden, p. 644, pl. xix., figs. 9–13.
1868. *Cypris salina*, Brady, Mon. rec. Brit. Ostrac., p. 368, pl. xxvi., figs. 8–13.
1870. *Cypris fretensis*, Brady and Robertson, Ann. and Mag. Nat. Hist., ser. iv., vol. vi., p. 13, pl. iv., figs. 7–9.
1874. *Cypris salina*, Brady, Crosskey, and Robertson, Post-tert. Entom., p. 124, pl. i., figs. 17–19.

The typical form of this species must, we think, be taken to be the banded variety described in the "Monograph of Recent British Ostracoda." In Fischer's description certain markings are noticed somewhat vaguely, but are not given in the figures accompanying his memoir, and the specimen on which *C. fretensis* was founded is destitute of markings altogether, but is otherwise indistinguishable from *C. salina;* the characters on which the separation was made now appear to us insufficient to mark a distinction of species.

Additional localities.—Several East Anglian localities have yielded the unbanded (*fretensis*) form—River Deben, Breydon Water, Lake Lothing, Somerton Broad, Whittlesea Dyke (B. and R.); Dykes on Cardiff Moor (Mrs. Robertson); Isle of Lewis (D. R.); Rainton, Co. Durham (A. M. N.)

Distribution.—Fischer's specimens were found near Palermo. Professor Lilljeborg has found it in Sweden (!), and we have specimens collected by Mr. E. C. Davison in the river Scheldt; by the Marquis de Folin, in Adour Maritime, France; and by Prof. Moniez at Lille; Pomerania (Wilh. Müller!).

Fossil.—Scotland (Crofthead).

10. *Cypris* (?) *cambrica*, Brady and Robertson.

(Plate VIII., figs. 12, 13.)

1872. *Cypris* (?) *cambrica*, Brady and Robertson, Ann. Nat. Hist., ser. IV., vol. ix., p. 55, pl. ii., figs. 3, 4.

Shell seen from the side, sub-triangular; greatest height situated behind the middle, and equal to half the length; anterior extremity obtusely, posterior rather obliquely rounded; superior margin boldly arched, slightly gibbous behind the middle; inferior almost straight. The outline, as seen from above, is elongated, with equally tapering acuminate extremities; greatest width in the middle, and considerably less than half the length. Shell thin, semi-transparent, yellowish. Length ·75 mm.

We are unable to add anything to what was previously written respecting the single specimen (an empty shell) on which this species was founded. The specimen was taken off Penarth Head, South Wales, on a muddy bottom, and may very probably have been washed down from fresh water.

11. *Cypris ornata*, O. F. Müller.

(Plate VIII., figs. 8, 9.)

1785. *Cypris ornata*, Müller, Entomostraca, p. 51, pl. iii., figs. 4–6.
1820. *Monoculus ornatus*, Jurine, Hist. Nat. des Monocles., p. 170, pl. iii., figs. 4–6.
1838. *Cypris conchacea*, Koch, Deutschlands Crustaceen, &c., H. xxi., 12, 13, 14.
1844. *Cypris ornata*, Zaddach, Synops. Crust. Prussic. Prodr., p. 33.
1853. *Cypris ornata*, Lilljeborg, De Crust. ex ord. tribus, p. 110, pl. x., figs. 19, 20; pl. xii., fig. 4.

Cypris ornata has been described by Müller, Jurine, and Lilljeborg, and these three authors seem to have had in view the same species; but Fischer appears not to have seen the true *C. ornata*, and describes under that name specimens referable to *C. virens*, which indeed he erroneously identifies with *C. ornata*.

Shell, seen from the side, oblong, sub-reniform, higher in front than behind; greatest height situated a little in front of the middle, and equal to half the length; extremities rounded, posterior much narrowed; superior margin much elevated in front of the middle, thence sloping with a gentle curve backwards; inferior sinuated in the middle. Seen from above, the outline is oblong-ovate, about twice as long as broad, widest in the middle, extremities acuminate and nearly equal. When placed in a favourable light under the microscope, the shell, especially towards the two extremities, exhibits a strongly reticulated epidermic covering,

the surface smooth and shining, bearing a few scattered hairs; variously coloured, but usually pale green, variously banded with dark green and orange. The setæ of the antennæ are well developed. Length 2·3 mm.

This is certainly one of the finest of European Ostracoda, both as to size and colouring. Those which come nearest in external appearance are *E. reptans*, and *E. strigata* to which it bears not a very distant relation in size, shape, and colour. The well-marked anterior elevation of the shell, and its greater width, are characters sufficiently distinctive, apart from the structure of the antennæ.

British localities.—The only known British specimens of this species were taken in a pond at Shotton Hall, Co. Durham, in May, 1855 (G. S. B.)

Distribution.—Sweden (Lilljeborg!); Denmark (Müller); Belgium (Plateau); France (Moniez); Prussia (Zaddach!); Pomerania (Wilh. Müller!); Switzerland (Jurine); Hungary (Orley); Transylvania (Daday).

12. *Cypris clavata*, Baird.

(Plate IX., figs. 15, 16.)

1853. *Cypris clavata*, Lilljeborg, De Crust. ex ord. tribus, p. 121, pl. xi., figs. 5–7 (but not synonyms).
1868. *Cypris clavata*, Brady, Mon. rec. Brit. Ostrac., p. 367.

Shell somewhat wedge-shaped, highest in front of the middle; height less than half the length; anterior extremity very obtuse, almost truncate, very high and broadly rounded; posterior much narrower, rounded, scarcely more than half the height of the anterior; dorsal margin gibbous in front of the middle, thence sloping with a long and tolerably even declination to the posterior extremity; ventral margin slightly incurved centrally, and a little convex at the extremities. Seen from above, lanceolate; breadth scarcely more than one-third the length; both extremities narrow, the anterior the narrower. Colour (in spirits) pale green, clouded with yellow, and two darker oblique lines behind the middle. Valves sparingly setose. Length 2·4 mm. The setæ of the antennal swimming brush reach to the apex of the claws, as in the typical Cyprides. The species cannot therefore be identified with *C. parabolica* (Koch), which, according to that author, is unable to swim.

The foreign specimen of this remarkably fine Cypris, from which we have drawn up the foregoing description, and which we have figured, is one of Lilljeborg's types, and was taken by him, June 6, 1852, at Nöbbelöf, near Lund, Sweden. We have also received examples, taken at Greifswald, in Pomerania, from Herr Wilh. Müller. There seems not the slightest reason to doubt that Lilljeborg was right in assigning his specimens to the *C. clavata* of Baird. It closely accords with figure and description of that species.

Dr. Baird found *C. clavata* "in a pond near Copenhagen Fields, July, 1836." That spot has long been built over. *C. clavata* has not since been found in our islands; but it must be remembered that those who have been working at the fresh-water Ostracoda have almost entirely confined their investigations to Scotland and the North and East of England. Much yet remains to be done in the South and West.

13. *Cypris fischeri*, Lilljeborg.

(Plate x., figs. 3, 4; Plate xii., fig. 2.)

1851. *Cypris fasciata*, Fischer, Ueber das Genus Cypris, p. 151, pl. v., gs. 9–12; pl. vi., figs. 1, 2; and pl. xi., fig. 9 (*non C. fasciata*, Müller).
1883. *Cypris fischeri*, Lilljeborg, International Fisheries Exhibition, London, Sweden Cat., p. 146.

Shell of female long, siliquose, highest behind the middle; height, scarcely more than one-third the length; anterior extremity broadly and a little obliquely rounded, most produced below; posterior extremity narrower than the anterior, greatest projection below the centre, and here a slight appearance of angularity, thence sweeping upwards and backwards to about one-third the length of the valves, where they attain their greatest height; dorsal margin consisting of the just described sweep behind, a central portion straight or even slightly concave, and in front of this, at the commencement of the anterior slope, another very slight sinuation; ventral margin slightly concave centrally; left valve larger than the right, which falls short of, and closes markedly within, it at the posterior extremity. Seen from above, three times as long as broad, with nearly parallel sides; termination in front acute, the sides there gradually converging; behind narrowly rounded, the over-lapping of the left valve is very evident by its projection. Colour (in spirit specimens), pale green, blotched with yellow centrally. The shell is furnished with long but scattered setæ, very conspicuous on the margin. Length 2 mm.

Specimens not quite adult are of nearly equal height throughout, with the dorsal line much straighter. It is from such a specimen that Fischer's figure appears to have been taken.

The antennæ are furnished with long plumose setæ at the end of the third joint. The abdominal rami (as correctly figured by Fischer) have the hinder side of the distant half of the limb minutely pectinate, with very microscopic spinules, and both claws have also very finely-pectinated edges.

The above description and the figures are made from specimens exhibited by Professor Lilljeborg at the International Fisheries Exhibition, which were found by him at Upsala, Sweden, June 7, 1882. The only other examples known are those taken by Fischer in Russia.

14. *Cypris trigonella*, Brady.

1868. *Cypris trigonella*, Brady, Mon. rec. Brit. Ostrac., p. 369, pl. xxv., figs. 41–44.

The only known specimens of this species are those mentioned in the "Monograph," as found by A. M. N., in a gathering made by the late Mr. George Barlee.

The French specimens recorded by Prof. Moniez under this name we find, from examples kindly sent to us, to be the young stage of *C. virens*.

15. *Cypris crassa*, Müller.

(Plate viii., figs. 10, 11.)

1785. *Cypris crassa*, Müller, Entomostraca, p. 61, pl. vi., figs. 1, 2.
1844. *Cypris ovata*, Zaddach, Syn. Crust. Prussic. Prodr., p. 37 (*non* Jurine).
1851. *Cypris dromedarius*, S. Fischer, Ueber das Genus Cypris, p. 153, pl. vii., figs. 5–9.
1883. *Cypris dromedarius*, Lilljeborg, International Fisheries Exhibition, London, Sweden Cat., p. 146.

Shell seen laterally, sub-reniform; greatest height situated near the middle, and equal to half the length; anterior extremity wide, obtuse, only very slightly rounded; posterior much narrower, produced and moderately rounded; the dorsal margin is not very strongly arched, and presents two gibbous elevations, the anterior being the more prominent of the two; there is a rather steep incurved slope towards the posterior extremity; ventral margin deeply sinuated in the middle Seen from above, ovate, more than twice as long as broad; widest in the middle; extremities produced and sharply mucronate. Swimming setæ of antennæ well developed. Shell-surface smooth, shining, and delicately reticulated. Length, 2·1 mm.

This species is described from specimens in Dr. Norman's collection, taken in Sweden by Professor Lilljeborg.

Distribution.—Sweden (Lilljeborg!); Russia (Fischer).

16. *Cypris bispinosa*, Lucas.

1868. *Cypris bispinosa*, Brady, Mon. rec. Brit Ostrac., p. 366, pl. xxvi., figs. 14–17.

Additional locality.—In a pool in a small island at Valentia, Ireland (A. M. N.).

This splendid species in the three localities in which it has occurred has been taken near the sea. It is probable, therefore, that it is an inhabitant only of water which is slightly brackish.

ADDITIONAL SPECIES RECORDED FROM N.-W. EUROPE, UNKNOWN TO US.

Cypris rubra (Jurine).

Plateau (p. 57) records this from Belgium. Jurine's description of *Monoculus ruber* is very brief, as follows: "Il diffère de l'orangé (i. e. *Cypris incongruens*) par une couleur moins vive, par un transparence moindre dans la coquille, et surtout par une large zône colorée qui latraverse dans le milieu. Longueur, $\frac{3}{4}$ de ligne."

The figure (pl. xviii., figs. 3, 4, Jurine), is very like that of *C. aurantia* (= *incongruens*), the only difference appearing to be a somewhat greater sinuation of the ventral margin. We doubt its specific distinctness.

Cypris quadripartita, Plateau.

Cypris quadripartita, Plateau, Les Crustacés d'eau douce de Belgique, p. 56, fig. 28.

M. Plateau gives the following description :—Valves seen laterally, almost exactly elliptical; seen from above moderately wide in the middle, and narrower in front than behind; seen endwise, the outline is triangular, with rounded angles, the upper angle corresponding with the hinge-line. (The figure shows a deep furrow in the middle of the ventral, and a shallow one on the dorsal margin.) Valves covered with short hairs and finely punctured; setæ of the antennæ and of the first pair of feet very short. Length, 1·3 mm. Colour, pale green, mottled with yellow, a line of dark brown along the dorsal margin, and another transversely across the middle of each valve. Those lines divide the surface into four equal parts, whence the name *quadripartita*.

M. Plateau found this species only once in the neighbourhood of Ghent.

Cypris strausii, Plateau.

Cypris Strausii, Plateau, Les Crustacés d'eau douce de Belgique, p. 55, fig. 26.

M. Plateau gives the following characters for this species :—Shell elongated, enlarged at the extremities, concave in the middle of the back; colour brown or grey, or almost white; valves marked with small brown patches; surface clothed with hairs; antennæ provided with very short setæ; ova with yellowish-brown nuclei. Length, 1·3 mm.

This species is quite unknown to us, and was found, in the month of May, by Professor Plateau at Sclayn (Namur) in ditches by the road between Namur and Andenne. It may be noted that M. Plateau's figure is not unlike *Limnicythere sancti-patricii:* it is, however, twice as large as the last-named species, and differs also in other respects.

Genus V.—Erpetocypris, n. g.

(From ἑρπετόν, a creeping thing.)

General characters of the animal closely approaching those of Cypris; but the setæ of the third joint of the lower antennæ are short, not nearly reaching the apex of the terminal claws, and are not plumose. The second pair of jaws have branchial plates, as in Cypris. The power of swimming is lost, and the habits of the animals, which creep along the bottom, are thus very different from those of Cypris.

[Type.—*Erpetocypris reptans* (Baird).]

1. *Erpetocypris reptans* (Baird).

(Plate xiii., fig. 27.)

Synonym : *C. virescens*, Brady.

1850. *Candona similis*, Baird, Brit. Entom., p. 162, pl. 19, figs. 2, 2*a* (*pullus*).
1868. *Cypris reptans*, Mon. rec. Brit. Ostrac., p. 370, pl. xxv., figs. 10–14 ; pl. xxxvi., fig. 4.
1870. *Cypris ornata*, Heller, Untersuch. über die Crustaceen Tirols, p. 92.
1872. *Cypris reptans*, Fric, Die Krustenthiere Böhmens, p. 226, fig. 24, *a–b*.
1872. *Candona similis*, Brady and Robertson, Ann. and Mag. Nat. Hist., ser. iv., vol. ix., p. 52, pl. i., figs. 1, 2.
1875. *Cypris reptans*, Brady, Crosskey, and Robertson, Post-tert. Entom., p. 128, pl. ii., figs. 31, 32.

This is a common British species.

C. ornata of Heller is, as shown by specimens kindly sent to us by Professor Heller, not the true *C. ornata*, but the present species.

The caudal rami have the posterior margins fringed with minute setæ arranged in six quite separate pectinated series of about eighteen each.

Distribution.—Norway (G. O. Sars); Sweden (Lilljeborg!); Prussia (Wilh. Müller, *in litt.*); Tyrol (Heller!); Bohemia (Fric); Palermo (A. M. N.); Lac d'Ossegor, Etang de la Négresse, etc., near Bayonne, S.W. France, Marquis de Folin (G. S. B.). ; Transylvania (Daday).

Fossil.—England.

2. *Erpetocypris strigata* (O. F. Müller).

(Plate VIII., figs. 14, 15.)

1785. *Cypris strigata*, O. F. Müller, Entomostraca, p. 54, pl. iv., figs. 4–6.
1838. *Cypris lutaria*, Koch, Deutschlands Crustaceen, H. 21, p. 15 (*variety*).
1844. *Cypris Jurinii*, Zaddach, Synops. Crust. Pruss. Prod., p. 36.
1851. *Cypris Jurinii*, Fischer, Ueber das Genus Cypris, p. 152, pl. vi., figs. 3–9; pl. vii., figs. 1–4.
1853. *Cypris Jurinii*, Lilljeborg. De Crust. ex ord. tribus, p. 110, pl. x., figs. 19–22; pl. xii., fig. 4.
1853. *Cypris lucida*, id., ib., p. 122, pl. xxv., figs. 7–10 (*variety*).
1870. *Cypris ornata*, Brady (*non* Müller), Nat. Hist. Trans. Northumb. and Durham, vol. III., p. 364, pl. xiv., figs. 1–3.
1883. *Cypris strigata*, Lilljeborg, Cat. International Fisheries Exhibition, London, Sweden Cat., p. 147.

Shell elongated, not much higher in front than behind; seen from the side, sub-ovate, broadly rounded in front, slightly narrower behind; superior margin evenly and moderately arched, highest in the middle; inferior nearly straight; height equal to rather more than half the length. Seen from above, oval, widest in the middle, and tapering evenly towards the ends, which are pointed; the anterior rather more obtuse than the posterior; width somewhat less than the height. End view almost circular. Surface of the shell smooth, variously banded with pale yellow and green. Setose brush of the antennæ very short, almost rudimentary. Length, 2·5 mm.

We have here taken as the type of *E. strigata* Swedish specimens so named by Professor Lilljeborg, which are now in the collection of Dr. Norman.

British localities.—Duddingston Loch, Ponds near Taymouth Castle and Port Glasgow, Mr. T. Scott (G. S. B.): Thornton Hall, Lanarkshire; Isle of Cumbrae; Burnside Loch, near Glasgow; Little Loch, near Barhead; and Hayston Dam, Peebles (D. R.): grassy pools at Tilmire, near York (A. M. N.); stream in Fulwell Cemetery, Sunderland (G. S. B.). These last-named specimens were originally referred (*loc. cit.*) to *C. ornata.*

Distribution.—Norway (G. O. Sars!); Sweden (Lilljeborg!); Denmark (Müller); Prussia (Zaddach!); Hungary (Orley); Russia (Fischer).

We have given *C. lucida* of Lilljeborg as a synonym of this species on the authority of the author, who writes to us that he is now convinced that the form described by him is "an example of *C. strigata* somewhat more than usually excavated at the lower margins of the valves."

3. *Erpetocypris fasciata* (O. F. Müller).

(Plate ix., figs. 13, 14; Plate xii., fig. 1.)

1785. *Cypris fasciata*, Müller, Entomostraca, p. 53, pl. iv., figs. 1–3.
1837. *Cypris ephippiata*, Koch, Deutschlands Crustaceen, H. 12, figs. 1, 2.
1844. *Cypris fasciata*, Zaddach, Synops. Crust. Pruss. Prod., p. 34.
1863. *Cypris angustata*, G. O. Sars, Om en i Sommeren 1862 foretagen Zoologisk Reise i Christianias og Trondhjems Stifter, p. 29.
1868. *Cypris fasciata*, Claus, Beit. zur Kennt. der Ostrac., Entwick. von Cypris, pl. i., figs. 9–11; pl. ii., figs. 12–21.
1870. *Cypris fasciata*, Heller, Untersuch. über die Crustaceen Tirols, p. 91.

Shell compressed, elongated; seen from the side, sub-triangular, or siliquose; greatest height in the middle, and equal to somewhat more than one-third of the length; extremities rounded, the posterior much narrowed; dorsal margin gently arched, steeper behind, and slightly incurved just in front of the hinder extremity; ventral nearly straight. Seen from above, the outline is compressed, ovate, thrice as long as broad, widest in the middle, and tapering evenly to the extremities, which are sharply acuminate. The surface of the shell is smooth, white, and marked with two conspicuous transverse green bands, the anterior band generally deeper in colour and more sharply defined than the posterior. Length, 1·55 mm.

The description is drawn from Swedish specimens in the collection of Dr. Brady, for which he was indebted to the kindness of Professor Lilljeborg. It may be noted that the green banding of the shell varies much in different specimens, and that though the anterior band is usually well defined, the posterior one is liable to become a diffuse clouding extending over a considerable portion of the shell; sometimes the two bands are coalescent, the shell taking on a general green colouration, and in other cases the colouring may be almost entirely absent.

The caudal rami have the distal hinder edge smooth, and not minutely pectinated, as in *C. fischeri*, while the claws are very strongly pectinated, instead of minutely so, as in the case of *C. fischeri*.

Distribution.—Norway (G. O. Sars, as *C. ephippiata*); Sweden (Lilljeborg!). Denmark (Müller); Prussia (Zaddach!); Pomerania (Wilh. Müller!); Tyrol (Heller!); Hungary (Orley); Bedestresser See, North Germany, S. A. Poppe! (G. S. B.)

4. *Erpetocypris serrata* (Norman).

1868. *Cypris serrata*, Brady, Mon. rec. Brit. Ostrac., p. 371, pl. xxv., figs. 15–19; pl. xxxvi., fig. 3.
1880. *Cypris bicolor*, Wilhelm Müller, Zeits. für ges. Naturwissensch., Bd. vi., p. 236, pl. iv., figs. 24–26.
1886. *Cypris zenkeri* (Toth and Chyzer), Orley, Ueber die Entomostraken Fauna von Budapest, p. 7. (Temieszetrajzi Füzetek., vol. x.)

Additional localities.—Whittlesea; River Nene at Peterborough (G. S. B. & D. R.).

Distribution.—Arnstadt, Thüringen (Wilh. Müller !), Hungary (Orley !); France (Moniez); Transylvania (Daday).

We are indebted to Herr Wilh. Müller for types of his *C. bicolor*, and to Professor Orley for types of the *C. zenkeri* of Toth and Chyzer. Herr Müller has already himself referred *C. bicolor* to the present species, of which also *C. zenkeri* is another synonym. The spirit-preserved specimens of the latter are of paler hue than British examples, the ground colour being light green; the spines of the anterior margin are not developed, as in the types, but the backward-directed spines of the posterior margin are present as usual.

5. *Erpetocypris tumefacta* (Brady and Robertson).

(Plate viii., figs. 5–7; Plate xiii., fig. 18.)

1870. *Cypris tumefacta*, Brady and Robertson, Ostracoda and Foraminifera of Tidal Rivers, Ann. Nat. Hist., ser. iv., vol. vi., p. 13, pl. iv., figs. 4-6.

Shell very tumid; seen from the side, sub-reniform, somewhat depressed in front; greatest height in the middle, and equal to rather more than half the length; extremities rounded; superior margin boldly arched; inferior gently sinuated in the middle. Seen from above, broadly ovate, acutely mucronate in front, well rounded behind; sides sub-parallel; greatest width situated in the middle, and rather greater than the height. End-view sub-rhomboidal, pointed above, broadly rounded below; sides excessively convex. Shell perfectly smooth, opaque white or cream-coloured, with clouded yellow patches, and sparingly coated with very fine hairs. Three tufts of very short non-plumose antennal setæ, one consisting of four setæ on the penultimate joint, another of seven or eight setæ on the antepenultimate, which also bears a fascicle of about four still smaller setæ. Length, 0·9 mm.

Seen laterally this species is not unlike *C. virens* or *C. incongruens*, but seen from above or endwise the difference of contour is very marked, being very gibbous.

British localities.—The types were found in Northumberland, but it has since been taken in the river Lathkill, Derbyshire, and near Sunderland (G. S. B.), and in the following Scotch localities by D. R.: Cumbrae; Peebles; Lochmaben;

Lochgoin; Yetholm; Eaglesham; and Bishop and Woodend Lochs: near Glasgow; also near Taymouth Castle; near Paisley; in pools near Greenan Loch. In pools by Loch Ascog and Loch Fadd; and at Tarbert, Loch Fyne (Mr. T. Scott).

Distribution.—Common in the neighbourhood of Christiania, Norway (G. O. Sars *in litt.*).

6. *Erpetocypris robertsoni*, n. sp.

Shell seen from the side, sub-reniform, highest just behind the middle; height equal to half the length; anterior extremity evenly rounded, posterior broader and obliquely rounded; dorsal margin boldly arched, rather depressed in front, the greatest height being behind the middle, forming a bold and steep curve backwards; ventral margin gently sinuated, and showing a slight protuberance near the middle; seen from above, regularly ovate, widest in the middle, and nearly thrice as long as broad, compressed and acuminate in front, rounded off behind. Surface of the valves smooth, greenish, mottled with markings of deeper green and brown. Length 1·6 mm.

Erpetocypris robertsoni.

Habitat.—Hayston Dam, Peebles; and Portree, Isle of Skye (*Mr. D. Robertson*).

It is very difficult to indicate a distinct line of separation between this species and *E. strigata* on one hand, and *E. olivacea* on the other. The difference in form of shell will be best appreciated if put in tabular form as follows:—

	Lateral View.	Dorsal View.
strigata,	highest in front, . . .	extremities nearly equal, moderately compressed, acuminate.
olivacea,	highest in middle, . .	extremities equal, very slightly tapered, broad, sub-acuminate.
robertsoni,	highest behind the middle, .	tapered and acuminate in front, rounded behind.

The caudal rami in *E. strigata* have the apical claws long and slender, and between them and the marginal seta there is a considerable interval; in *E. robertsoni* the two principal claws are short and stout and not much curved, while the marginal seta is very small and slender, and is closely approximated to the rest; in *E. olivacea* the apical claws are, as in *E. robertsoni*, short and stout, the marginal seta being also very thick, and separated by a short interval from the others.

E. robertsoni has been found only in two localities: Hayston Dam, near Peebles, and in the river at Portree, Isle of Skye. In both places it was taken by our friend Mr. David Robertson, after whom we have much satisfaction in naming it.

7. *Erpetocypris olivacea*, nov. sp.

(Plate I., figs. 3, 4.)

Shell seen from the side, elongated, subreniform, greatest height in the middle, and equal to half the length; anterior extremity evenly, posterior obliquely rounded, dorsal margin forming a flattened arch, and sloping more steeply behind than in front; ventral gently sinuated; seen from above, ovate; more than twice as long as broad, widest in the middle, extremities obtusely pointed and nearly equal; shell smooth and shining, transparent, mottled, deep olive green. Length, 1·4 mm.

This pretty species was found abundantly amongst weeds in the River Lathkill, Derbyshire, in August, 1885 (G. S. B.). Duddingston Loch, near Edinburgh, 1887, Mr. T. Scott!

Genus VI.—Cypridopsis, Brady.

[Type, *C. vidua* (Müller).]

1. *Cypridopsis vidua* (Müller).

Synonym: *C. sella*, Baird.

1837. *Cypris maculata*, Koch, Deutschlands Crustaceen, &c., H. 10, 2.

184(4 ?). *Cypris strigata*, idem, ibidem, H. 36, 19.

1868. *Cypridopsis vidua*, Brady, Mon. rec. Brit. Ostrac., p. 375, pl. xxiv., figs. 27–36, 46.

1868. *Cypris vidua*, Claus, Beiträge zur Kenntniss der Ostracoden, Entwickelungsgeschichte von Cypris, pl. i., figs. 6–8.

1869. *Cypridopsis obesa*, Brady and Robertson, Ann. Nat. Hist. ser. IV., vol. iii., p. 364, pl. xviii., figs. 5–7.

1870. *Cypridopsis obesa*, idem, ibidem, ser. IV., vol. vi., p. 15.

1870. *Cypris vidua*, Heller, Unters. über die Crustaceen Tirols, p. 90.

1872. *Cypris vidua*, Fric, Die Krustenthiere Böhmens, p. 227.

1874. *Cypridopsis obesa*, Brady, Crosskey, and Robertson, Post-tert. Entom., p. 128, pl. i., figs. 1–4.

The banded typical form of *C. vidua* is widely distributed in fresh water. The form for which the specific name *obesa* was proposed differs in being devoid of coloured bands, and usually of rather coarser appearance. It occurs commonly in brackish or sub-brackish water, though by no means confined to situations of that kind.

Distribution.—Norway (G. O. Sars); Sweden (Lilljeborg!); Denmark (O. F. Müller); Prussia (Zaddach!); Switzerland (Jurine); Thuringen (Wilh. Müller, *in litt.*); Tyrol (Heller); Bohemia (Fric); Hungary (Orley); Russia (Fischer); Botanical Gardens, Palermo (A. M. N.); North Germany (Poppe!); Normandy (Moniez); Transylvania (Daday).

Fossil.—England.

2. *Cypridopsis aculeata* (Lilljeborg).

1868. *Cypridopsis aculeata*, Brady, Mon. rec. Brit. Ostrac., p. 376, pl. xxiv., figs. 16–20; pl. xxxvi., fig. 10.

1838. *Cypris villosa*, Koch, Deutschlands Crustaceen, &c., H. 21, 24.

Additional localities.—Scilly Islands, many of the broads of Norfolk and Suffolk, and dyke at Whittlesea (G. S. B. & D. R.): River Thames; very abundant at Monkton Paper Mills Co. Durham (G. S. B.): Cardiff Moor (Mrs. Robertson): Seaton Delaval, Northumberland; Belfast; Newport, Co. Mayo (A. M. N.): Tarbert, Argyleshire, Mr. T. Scott (G. S. B.): Isle of Skye (D. R.).

Distribution.—Sweden (Lilljeborg !); River Scheldt, Holland, Mr. E. C. Davison (G. S. B.); Finland (Cajander); Transylvania (Daday).

3. *Cypridopsis villosa* (Jurine).

Synonyms: *Cypris westwoodii* and (?) *elongata*, Baird.

1868. *Cypridopsis villosa*, Brady, Mon. rec. Brit. Ostrac., p. 377, pl. xxiv., figs. 11–15; pl. xxxvi., fig. 9.

Additional localities.—Lakes of Mayo and Galway (G. S. B. & D. R.): Newbiggin, Northumberland (A. M. N.): pond near Taymouth Castle, and in pools near Lochs Fadd and Ascog, T. Scott (G. S. B.): Baslow, Derbyshire; Welbourn, Lincolnshire; Loch Fergus, Kircudbrightshire (G. S. B.): Isles of Skye and Lewis (D. R.).

Distribution.—Sweden (Lilljeborg!); Belgium (Plateau); Switzerland (Jurine); Germany (Koch); France (Moniez).

4. *Cypridopsis* (?) *newtoni*, Brady and Robertson.

(Plate viii., figs. 16, 17.)

1870. *Cypridopsis* (?) *newtoni*, Brady and Robertson, Ann. Nat. Hist., ser. iv., vol. vi., p. 14, pl. vii., figs. 14–16.

1874. *Cypridopsis* (?) *newtoni*, Brady, Crosskey, and Robertson, Post-tert. Entom., p. 129, pl. ii., figs. 20, 21.

Carapace, as seen from the side, reniform; greatest height in the middle, and equal to a little more than half the length; extremities rounded, the anterior being the broader of the two; superior margin boldly and evenly arched; inferior sinuated in the middle. Seen from above, compressed, ovate, acuminate in front, rounded behind; greatest width situated near the middle, much less than the height. Surface of the shell punctate, and covered with numerous appressed hairs. Colour, dull green. Length, ·85 mm.

Our examples of this species are not numerous, and we have not been successful in finding perfect specimens of the contained animal. The postabdominal rami are rudimentary, as in Cypridopsis; but the lower antennæ seem to be destitute of the setose brush, which in that genus is usually very long. The species would therefore appear to be an aberrant one; but without a thorough acquaintance with its internal structure, we think it best for the present to place it in the genus to which it is here assigned. It approaches closely in external appearance to *Cypridopsis villosa* and *Potamocypris fulva*, but is larger than either, more tumid, less strongly arcuate, and coarser in texture than the former; while the almost equal and well-rounded valves, coarsely hispid surface, and ovate form when seen from above, sufficiently distinguish it from the latter.

Habitat.—Hayston Dam, Peebles; Little Loch and Pilmuir Dam, Renfrewshire; Isles of Cumbrae and Bute (D. R.): Rivers Nene and Cam; and dykes on the site of Whittlesea Mere (G. S. B. & D. R.): Loch Ruter, Kirkcudbrightshire (A. M. N.).

Fossil.—England (Whittlesea).

5. *Cypridopsis variegata*, nov. sp.

(Plate VIII., figs. 20, 21.)

Shell seen from the side, sub-reniform, greatest height situated just in front of the middle, and equal to two-thirds of the length; anterior extremity broad, well-rounded; posterior narrower, obliquely truncated; dorsal margin boldly arched, almost gibbous; ventral sinuated in the middle; seen from above, ovate, fully twice as long as broad, extremities sub-acuminate. The right valve is larger and more rounded in outline than the left, which it overlaps (though not so broadly as in *Potamocypris fulva*) on the dorsal, ventral, and posterior margins. The shell is marked throughout with closely-set, small, rounded impressions, and in the Lough Neagh specimens is ornamented with black bands, the ground colour being yellowish. Length, ·55 mm.

This species occurred sparingly in several gatherings made years ago, in the English Fen District, by Messrs. Brady and Robertson; but on account of its close resemblance to *Potamocypris fulva* and *Cypridopsis newtoni* it remained undescribed. Specimens recently obtained by Mr. Robertson in the Isle of Skye, and by Dr. Norman from a pool by the side of Lough Neagh, Ireland, by their very characteristic colouring, seem to leave no doubt as to its specific distinctness. The Fen district localities are the following: River Cam, at Ely; River Nene, at Peterborough; and dykes near Whittlesea.

6. *Cypridopsis picta* (Straus).

(Plate x., figs. 30, 31.)

1821. *Cypris picta*, Straus-Durckheim, Mém. sur les Cypris (Mém. du Muséum, vol. vii.), p. 59, pl. i., figs. 17–19.
1867. *Cypris picta*, Plateau, Recherches sur les Crust. d'eau douce de Belgique, p. 50.

Shell sub-ovate, tumid; greatest height central, about equal to half the length; anterior extremity narrower than the posterior, well rounded; posterior extremity broadly and evenly rounded; dorsal margin well arched throughout; anterior declination steeper than the posterior; ventral margin sinuated in the middle. Seen from above, ovate; greatest breadth rather behind the middle, equal to the height, or half the length; the meeting of the valves in front is at an acute angle, but the hinder extremity is broadly rounded. Valves finely punctate, with a few scattered hairs. Spirit-preserved specimens are dark-green, with a white transverse band near the front. In such specimens, however, the animal is shrunk up towards the front part of the shell, which perhaps accounts for the apparent absence of two bands behind. Straus says: "Couleur verte, avec trois bandes, grises de terminant en joint en dessous." Length, ·4 mm.

We are indebted to Professor G. O. Sars for specimens of this species taken at Christiania, Norway. It has not been found in Britain.

The other recorded localities are: France (Straus-Durckheim); Belgium (Plateau).

C. picta may be distinguished from *C. vidua*, its nearest ally, by its smaller size, lesser obesity—though it is more tumid than the other species of the genus—by the anterior extremity being less high in proportion to the posterior when viewed laterally, and narrower in proportion to the posterior when looked at from above.

Genus VII.—POTAMOCYPRIS, Brady (1870).

[Type, *P. fulva*, Brady.]

Shell compressed; seen from the side, similar to that of Cypridopsis; valves unequal, the right much the larger, and overlapping on the dorsal and middle of the ventral margin; dorsal margin of the left valve somewhat flattened, that of the right boldly arched; hingement simple. Antennules seven-jointed, bearing a terminal brush of long, slender setæ. Antennæ geniculated, four-jointed, third and fourth joints bearing numerous setæ, which however are short, not

reaching beyond the middle of the terminal claws; last joint with two strong curved terminal claws, and two or three short, slender setæ. Mandible stout; palp three-jointed, and bearing a single branchial seta near the base. There is no verticillate duct ("glandula mucosa"), and the copulative organ is comparatively small and simple in structure. Feet as in Cypris. Caudal rami rudimentary, consisting only of a single slender seta.

Potamocypris fulva, Brady.

(Plate xxii., figs. 13–17.)

1868. *Bairdia fulva*, Brady, Mon. rec. Brit. Ostrac., p. 474, pl. xxviii., fig. 21.
1869. *Bairdia fulva*, Brady and Robertson, Ann. and Mag. Nat. Hist., ser. iv., vol. iii., p. 366, pl. xviii., figs. 1–4.
1870. *Potamocypris fulva*, Brady, Nat. Hist. Trans. Northum. and Durham, p. 366, pl. xiv., fig. 4.
1874. *Potamocypris fulva*, Brady, Crosskey, and Robertson, Post-tert. Entom., p. 130, pl. i., figs. 20–24.

Originally described from a specimen found in Scarpa Bay, Orkney; and a single valve in shell-sand from Roundstone. It has since that time been found in the following localities: Montrose Basin; Port Glasgow; Kames' Bay, Cumbrae; Birturbuy Bay; River Liffey, at Dublin (G. S. B. & D. R.): at Fulwell Cemetery, Sunderland; near the mouths of several rivers in Northumberland—Warn Burn, rivers Coquet, Wansbeck, and Blyth; in the canal at Ackworth, Yorkshire (G. S. B.): in dredgings from Rothesay Bay and Cumbrae: off Penarth Head, near Cardiff; in the Isle of Skye, and at Rowan Bridge, Lewis; and in dykes on Cardiff Moor (D. R.). In a pond near Taymouth Castle; in pools near Loch Fadd and Loch Ascog; and at Tarbert, Loch Fyne, Mr. T. Scott (G. S. B.).

It is most likely that the dredged specimens—all empty shells—were washed down out of fresh or brackish water. The only perfect animals (with soft parts intact) were from Fulwell Cemetery and Loch Ascog. In these cases the colour of the shell was green, so that the colourless or dirty yellow valves, as they usually occur, have probably undergone a *post mortem* bleaching.

The shell of this species has already been so abundantly figured that it is unnecessary to give further drawings.

Genus VIII.—AGLAIA, Brady.

[Type, *Aglaia pulchella*, Brady.]

Aglaia, Brady, Les Fonds de la Mer, tome premier, p. 90.

Shell smooth and polished, of nearly equal height before and behind, compressed, sub-cylindrical. Antennules seven-jointed, beset with short setæ. Antennæ robust, and bearing at the extremities of the joints several strong curved setæ, furnished also with a small hyaline vesicle, and on the penultimate joint with a lash of very short setæ. Mandibles slender, divided at the extremity into about five blunt teeth, and furnished with a long and narrow branchial palp. First pair of jaws divided into four digitate segments, and having a distinct branchial appendage; second pair also provided with a branchial lamina and simple conical three-setiferous palp. First pair of feet long, five-jointed, with a very long terminal claw; second pair different from the first, flexuous, four-jointed, last joint armed with three setæ, of which one is very long and finely pectinated on the inner margin. Post-abdominal rami moderately robust, bearing two curved terminal claws, one seta on the anterior and two on the posterior margin. Testes disposed round the body of the animal; verticillate duct elongated, and bearing seven whorls of filaments.

Aglaia complanata, Brady and Robertson.

(Plate XIV., figs. 28, 29.)

1869. *Aglaia complanata*, Brady and Robertson, Ann. and Mag. Nat. Hist., ser. iv., vol. iii., p. 66, pl. xx., figs. 4, 5.

Carapace, as seen from the side, oblong, sub-reniform, highest about the middle; greatest height equal to less than half the length; extremities rounded; superior margin evenly but slightly arched; inferior almost straight. Seen from above, compressed, ovate, extremities pointed; greatest width in the middle, and not much exceeding one-fourth of the length. Surface of the valves smooth, bearing a few short, scattered hairs; shell thin and fragile; lucid spots arranged in an irregular rosette. Length, ·65 mm.

Dredged in Westport Bay, in a depth of four fathoms; also in Roundstone Bay (G. S. B. & D. R.): Birturbuy Bay, Ireland (A. M. N.). The generic description, so far as the soft parts are concerned, is founded upon an examination of a Mediterranean species (*A. pulchella*). We have had no opportunity of seeing the internal parts of *A. complanata*.

Genus IX.—Paracypris, G. O. Sars.

[Type, *Paracypris polita*, G. O. Sars.]

Paracypris polita, G. O. Sars.

1868. *Paracypris polita*, Brady, Mon. rec. Brit. Ostrac., p. 378, pl. xxvii., figs. 1–4 ; pl. xxxviii., fig. 2.
1874. *Paracypris polita*, Brady, Crosskey, and Robertson, Post-tert. Entom., p. 131, pl. xv., figs. 9, 10.
1878. *Paracypris polita*, Brady, Mon. Ostrac. Antwerp Crag, p. 381, pl. lxiii., fig. 5.
1880. *Paracypris polita*, Seguenza, Le formazioni terziarie nella provincia di Reggio (Calabria), p. 361.
1880. *Paracypris polita*, Brady, Report Ostrac. "Challenger" Exped., p. 32.
1883. *Paracypris polita*, Seguenza, Il Quaternero di Rizzolo II. Gli Ostracodi, p. 3.
1885. *Paracypris polita*, Carus, Prod. Faunæ Mediterraneæ, p. 314.

Additional localities.—The Scilly Islands; Roundstone Bay and Mulroy Lough, Ireland (G. S. B. and D. R.): The Minch; Balmacarra, Sound of Skye; off Tarbert, Loch Fyne, 25 fathoms; Killary Bay (A. M. N.).

Distribution.—Langesund and Flekkefiord, in West Norway, 4–10 fath. (G. O. Sars); off Sartoro, Bergen Fiord, 15–40 fath.; Hardanger Fiord, off Lervig, 20–100 fath.; Fosse de Cap Breton, Bay of Biscay, 180–200 fath.; off Capri, Bay of Naples, 40 fath. (A. M. N.); Vigo Bay, Spain (G. S. B.); Messina (Seguenza); Wellington Harbour, New Zealand, 420 fath., "Challenger" (?) (G. S. B.).

Fossil.—Scotland; Norway; Calabria; Sicily.

Genus X.—Notodromas, Lilljeborg.

[Type, *N. monacha* (Müller).]

The characters which distinguish this genus from the following—Cyprois—are as follows:—The shell is usually ribbed or keeled on the ventral surface. The antennæ are not pediform; antepenultimate joint with the usual sensory organ and a brush of very long swimming setæ, which stretch beyond the extremities of those springing from the last joint; penultimate and terminal joints cylindrical and very slender, the latter as long or longer than the preceding, terminating in three slender setæ without claws or spines (*vide* Brady, Monogr., Pl. xxxvii., fig. 3 *b*). Branchial filaments of the mandible not attached to a lamina of their own, but directly to the palp and directed downwards. The second pair of maxillæ without branchial appendages; in the male the palps very strongly developed and different on the two sides. Feet of the first pair small and terminating in three setæ, the middle one claw-like, and about twice as long as the other two. Caudal rami with three claws at or near the extremity.

Notodromas monacha (Müller).

1844. *Cypris monacha*, Zaddach, Syn. Crust. Pruss. Prod., p. 31.
1837. *Cypris variabilis* (very young), Koch, Deutschlands Crustaceen, &c., H. 10, 3.
1837. *Cypris leucomela* (young), idem, ibidem, H. 10, 4.
1837. *Cypris monacha* (adult male), idem, ibidem, H. 11, 1.
1837. *Cypris bimuricata* (adult female), idem, ibidem, H. 11, 2.
1837. *Cypris nubilosa* (half-grown), idem, ibidem, H. 12, 4.
1851. *Cypris monacha*, Fischer, Ueber das Genus Cypris, p. 146.
1854. *Cyprois monacha*, Zenker, Monog. der Ostracoden (Archiv für Naturgesch.), p. 80, pl. iii. *C.*
1868. *Notodromas monachus*, Brady, Mon. rec. Brit. Ostrac., p. 379, pl. xxiii., figs. 1–9 ; pl. xxxvii., fig. 3.
1870. *Notodromas monachus*, Heller, Unters. über die Crustaceen Tirols, p. 78.
1872. *Cypris monacha*, Fric, Die Krustenthiere Böhmens, p. 228.
1885. *Notodromas monachus*, Nordquist, Beitrag zur Kenntniss der inneren männlichen Geschlechtsorgane der Cypriden, pls. i., ii., and iv.

Additional localities.—Gumley, Leicestershire; Newport, Co. Mayo (A. M. N.): Lochmaben; Somerton Broad, Norfolk, and Coolbareen Lough, Co. Mayo (G. S. B. and D. R.): in pools by Loch Fadd, Co. Bute (Mr. T. Scott, G. S. B.).

Distribution.—Norway (G. O. Sars); Sweden (Lilljeborg !); Denmark (Müller); Belgium (Plateau); Germany (Zenker, &c.); Bohemia (Fric); Switzerland (Jurine); Tyrol (Heller); Hungary (Orley); Russia (Fischer); Finland (Cajander); Normandy (Moniez); Transylvania (Daday).

Genus XI.—Cyprois, Zenker.

[Type, *C. flava* (Zaddach.)]

Shell compressed ventrally, and destitute of ribs or keel. Antennæ stout, the last joint short and very narrow, bearing at the apex a twisted ungüiform spine, the distal half of which is pectinated with two series of marginal setæ; also four simple setæ almost half as long as the spine, and two much smaller ones; the penultimate joint bears three long, slender setæ, one of which is pectinated, and in front of these a much stronger twisted and pectinated spine like that of the apical joint, but larger; antepenultimate joint furnished with the usual sensory organ, and at its extremity with a group of long swimming setæ. Second pair of maxillæ provided with a rudimentary branchial appendage of six plumose setæ.* Caudal rami bearing four or five claws at or near the extremity.

* This is not shown in Professor Orley's figures of the organs in *C. madaraszi;* indeed he states in the text of his memoir that it is wanting. This, however, is an oversight: it is clearly shown in our preparations, and closely resembles the same organ in *C. dispar.*

The male is smaller than the female (in *C. flava*), and more evenly rounded at the posterior extremity. The palp of the second maxillæ is prehensile and different on the two sides. Reproductive organs as in Notodromas.

A grand species, by far the largest of European Podocopa, has been described from Hungary by Professor Orley, under the name *Notodromas madaraszi* (Természetrajzi Füjetek, vol. x., 1886, p. 11, Pls. x. xi.). It is not a true Notodromas, and will fall into the present genus as *Cyprois madaraszi.*

The name Cyprois was proposed by Zenker as a sub-generic term to include two species, *C.* (*Notodromas*) *monacha* and *C. flava.* The two forms agree in the structure of the male reproductive apparatus, but the characters both of the shell and of the contained animal seem to require that they should be placed in different genera. In Notodromas the form of the shell in the two sexes is widely different, and quite distinct from that of Cypris, whereas in *C. flava* the shell presents no great sexual differences of form. We have, moreover, been favoured by Professor G. O. Sars with specimens of the two sexes of *C.* (*Cyprois*) *dentato-marginata*, Baird, raised from Australian mud; and in these the male organs are exactly similar to those of Cyprois. It is remarkable that in both cases (*C. flava* and *C. dentato-marginata*) the caudal rami are abnormal in having four rather long marginal setæ attached near the extremity, thus differing from Cypris, which has two long terminal and one shorter lateral seta.

Cyprois flava (Zaddach).

(Plate VIII., figs. 18, 19; Plate XII., figs. 13–21, 38.)

1838. (?) *Cypris gibbosa*, Baird, Mag. Zool. and Bot., vol. II., p. 137, pl. v., fig. 15; Nat. Hist. Brit. Entom. (1850), p. 156, pl. xix., fig. 8.

1844. *Cypris flava*, Zaddach, Syn. Crust. Pruss. Prodr., p. 33.

1851. *Cypris dispar*, Fischer, Ueber das Genus Cypris, p. 142, pl. i., figs. 1–12; pl. ii., figs. 1–6.

1854. *Cyprois dispar*, Zenker, Monographie der Ostracoden (Archiv für Naturgesch.), p. 81.

1883. *Cyprois dispar*, Lilljeborg, International Fisheries Exhibition, London, Sweden Cat., p. 147.

Shell of the female seen from the side, sub-triangular or sub-reniform; greatest height situated in the middle and equal to two-thirds of the length; anterior extremity broadly and evenly rounded; posterior oblique, steeply sloping, and rounded off at the inferior angle; dorsal margin boldly arched; inferior slightly sinuated in the middle. Seen from above, the outline is sub-ovate, more than twice as long as broad, widest in the middle, much compressed in front, anterior extremity slender, and sharply-pointed; posterior narrow and rounded off, scarcely pointed. Surface smooth and polished, marked with minute polygonal areolæ,

and bearing a very few fine appressed hairs. The hinder half of the valves in the male is occupied by a series of four concentric U-shaped, opaque streaks, with intermediate lines of perfectly pellucid shell, the whole enclosing a peninsula of unmarked shell: these markings coincide with the convolutions of the spermatic tubes (testes) which are apparent through the shell; and curvilinear markings corresponding with the ovarian tubes—entirely opaque and comparatively indistinct—may usually be observed in the same region of the female shell. Length of the male, 1·30 mm.; of the female, 1·75 mm.

Habitat.—Duddingston Loch, near Edinburgh (A. M. N.).

Distribution.—Norway (G. O. Sars); Sweden (Lilljeborg!); Russia (Fischer); Hungary (Orley); Prussia (Zaddach!).

Genus XII.—Candona, Baird.

[Type, *C. candida* (Müller).]

1. *Candona candida* (Müller).

(Plate x., figs. 1, 2, and 14–23.)

Synonym: *Candona lucens*, Baird.

1837. *Cypris pellucida* (?), Koch, Deutschlands Crustaceen, &c., H. 11, 5.
1868. *Cytheridea zetlandica*, Brady, Mon. rec. Brit. Ostrac., p. 428, pl. xxviii., figs. 42–46.
1868. *Candona candida*, Brady, Mon. rec. Brit. Ostrac., p. 383, pl. xxv., figs. 1–9, pl. xxxvi., fig. 13, and pl. xxxvii., fig. 1.
1870. *Candona candida, var. tumida*, Brady and Robertson, Ann. Nat. Hist., Ser. 4, vol. vi., p. 16, pl. ix., figs. 13–15.
1870. *Candona candida*, Heller, Untersuch. über die Crustaceen Tirols, p. 94.
1872. *Cypris candida*, Fric, Die Krustenthiere Böhmens, p. 227.
1874. *Candona candida*, Brady, Crosskey, and Robertson, Post-tert. Entom., p. 135, pl. ii., figs. 29, 30.
1885. *Cypris candida*, Nordquist, Beitrag zur Kenntniss der inneren männlichen Geschlechtsorgane der Cypriden, p. 25, fig. 27.

Common everywhere throughout the British Isles.

Distribution.—Norway (G. O. Sars); Sweden (Lilljeborg!); Denmark (Müller); River Scheldt, Holland (G. S. B.); Belgium (Plateau); Germany (Zenker, Zaddach, &c.); Switzerland (Jurine); Tyrol (Heller); Bohemia (Fric); Hungary (Orley); Russia (Fischer); Lac d' Ossegor, Cap Breton, S.W. France, Marquis de Folin (G. S. B.); Normandy (Moniez!); Transylvania (Daday).

The typical form of this species we take to be that figured as such in the "Monograph of recent British Ostracoda," but variations from the type are very numerous, and two of these seem to require recognition as named varieties—*C. tumida* and *C. claviformis*.

The variety *tumida* (Plate x., figs. 14–17) is much shorter and stouter than the typical form, the greatest height in the female equalling nearly two-thirds of the length; the width more than half the length; the outline, as seen from above, almost elliptical. The male is much higher, and also more tumid than in the ordinary form of the species. Lucid spots arranged in a rosette, five in number, each broadly cuneiform, with its apex directed towards the centre of the group. Intermediate forms are not unfrequently met with, but the tumid variety may usually be distinguished by the rosette-like disposition of the muscle-spots.

The male of the variety *claviformis* (Pl. x., figs. 1, 2) is, seen laterally, very narrow, with an almost straight dorsal line, sloping gently towards the highest part of the shell, which is situated very near the posterior extremity, thence falling steeply backwards; ventral margin very deeply sinuated in the middle; height equal to about half the length. The shell of the female is a little higher in front, the ventral sinuation shallower, and the posterior margin oblique, and not so broadly rounded. A form very closely approaching *C. neglecta*, Sars,* is represented in Plate x., figs. 18–21. Figs. 18, 19 are from shells (female) taken in a canal at Ackworth, Yorkshire. Figs. 20, 21 are from male shells found in a pond at Sunderland. Figs. 22, 23 is a female shell of the ordinary type, but with conspicuous reticulation near the extremities, also from Sunderland.

The ordinary form of *C. candida* occurs commonly in ponds and ditches; the variety *tumida* is most common in rivers and dykes subject to tidal influence, as in the Fen district of Norfolk and Suffolk, in the rivers Nene and Cam, and in the Warn Burn, Northumberland (G. S. B. and D. R.). The variety *claviformis* was found in a pond at Sedgefield, county Durham (A. M. N.).

At the time of the publication of the "Monograph," the variety *tumida* was unknown, and the Ostracod named *Cytheridea zetlandica*, having been found in the sea, was taken to belong to the genus to which it was assigned. But as it exactly corresponds with the variety *tumida*, we conclude that it must have been washed into the sea, and it is now expunged from our list.

* Nye Bidrag til Kundskaben om Middelhavets Invertebratfauna, iv. Ostracoda Mediterranea. (Archiv for Mathem. og Naturvidenskab, 1887, p. 107, pl. xv., figs. 5–7; pl. xix.)

2. *Candona elongata*, nov. sp.

(Plate x., figs. 24–27.)

Shell of the male (?) elongated, reniform; seen laterally, more than twice as long as high; greatest height behind the middle; anterior extremity evenly rounded, posterior narrower and sub-angular; dorsal margin almost horizontal for about one-third of its length at and somewhat behind the middle, thence sloping with an almost imperceptible curve, steeply behind but more gently towards the front; ventral margin very deeply sinuated in the middle. Seen from above, elongated, sub-ovate, more than twice as long as broad, widest in the middle; extremities pointed; surface smooth and polished; yellowish white. Length, 1·4 mm. Female unknown. A form which we take to be the young male (figs. 24, 25) is rather smaller, with a less strongly arched dorsal margin, and the ventral margin upturned and sinuated behind.

Lough Neagh, Ireland (A. M. N.).

3. *Candona lactea*, Baird.

1868. *Candona lactea*, Brady, Mon. rec. Brit. Ostrac., p. 382, pl. xxiv., figs. 55–58.

1868. *Candona detecta*, Brady (variety), Mon. rec. Brit. Ostrac., p. 384, pl. xxiv., figs. 35–38; pl. xxxvii., fig. 2.

1874. *Candona lactea*, Brady, Crosskey, and Robertson, Post-tert. Entom., p. 134, pl. i., figs. 14–16.

1874. *Candona detecta*, Brady, Crosskey, and Robertson (variety), Post-tert. Entom., p. 134, pl. i., figs. 7–9.

C. lactea approaches closely the young of *C. candida*, with which it has, no doubt, been generally confounded on the Continent. The young of *C. candida* may, however, be distinguished by being obliquely rounded behind, most produced below the middle, whereas in *C. lactea* both extremities are evenly rounded. It is common in Britain.

Distribution.—Rivers Scheldt and Maas, Holland (G. S. B.); Lac d'Ossegor, Cap Breton, S. W. France; Marquis de Folin (G. S. B.).

Fossil.—Scotland; England; South Wales; Ireland.

4. *Candona pubescens* (Koch).

(Plate XII., figs. 32–37.)

Synonym : *Cypris setigera*, Jones.

1837. *Cypris pubescens*, Koch, Deutschlands Crustaceen, &c., H. 11, p. 5.
1838. (?) *Cypris compressa*, idem, ibidem, H. 21, p. 17.
1868. *Candona compressa*, Brady, Mon. rec. Brit. Ostrac., p. 382, pl. xxvi., figs. 22–27.
1868. *Candona albicans*, idem, ibidem, p. 381, pl. xxv., figs. 20–25 ; pl. xxxvi., fig. 12 (junior).
1874. *Candona albicans*, Brady, Crosskey, and Robertson, Post-tert. Entom., p. 133, pl. i., figs. 10–18 (junior).

Additional localities.—Not uncommon in the Scottish Lowland lakes; generally distributed through the East Anglian Fen district (G. S. B. and D. R.): Ellesmere Canal, Blackmere, Colmere, and Osmere, Shropshire (G. S. B.) ; Duddingston Loch, Edinburgh; pond in Lumley Dene, Seaton Carew Marshes, and Sedgefield, all in the county of Durham; Tilmire, near York (A. M. N.): Lindores Loch, Fife (Mr. T. Scott).

Distribution.—Norway (G. O. Sars); Sweden (Lilljeborg !); Germany (Koch); Russia (Fischer); Lac d'Ossegor, Cap Breton, S. W. France; Marquis de Folin (G. S. B.) ; Normandy (Moniez) ; Transylvania (Daday).

Fossil.—England.

The form hitherto known to us as *C. albicans* probably includes the young of more than one species, all characterized by a very close and distinct punctation of the shell. By far the greater number of these are doubtless referable to *C. pubescens*, this being the form figured in the "Monograph of recent British Ostracoda;" but the young of *C. rostrata* scarcely differs, except in being much more compressed and acuminated in front.

5. *Candona rostrata*, nov. sp.

(Plate IX., figs. 11, 12, 12*a* and *b* ; Plate XII., figs. 22–31.)

1851. *Cypris compressa*, Fischer, Ueber das Genus Cypris, p. 144, pl. ii., figs. 7–12 ; pl. iii., figs. 1–5.

Shell seen from the side, sub-reniform, much higher behind than in front, greatest height equal to more than half the length; posterior extremity very broad and boldly rounded; anterior narrower and more flattened; median third of the superior margin almost straight, sloping with a steep curve towards the posterior extremity, and even more steeply and with a distinct sinuation, to the front; inferior margin deeply sinuated in the middle. Seen dorsally; the outline is

narrow sub-ovate, the anterior extremity compressed and flexuously produced in a mucronate manner; posterior rounded off and not produced; greatest width situated in the middle, and equal to rather more than one-third of the length. End view, ovate, rounded above, mucronate below. The shell is thin, smooth, beset with fine, long hairs, yellowish, with cloudings of chestnut brown. Length, 1·2 mm. The left valve is considerably less than the right, its margin being received within that of the opposite valve for the greater part of its circumference. General structure of the soft parts as in *C. fabæformis.*

This seems to be a distinct and well-characterized species. The one or two specimens which we have dissected are males, showing verticillate ducts of a similar type to those of *C. kingsleii* and *C fabæformis.* This, together with the fact that we have as yet found no females, leads to a suspicion that they may perhaps belong to some species, the females of which are already well known, and possibly very different in shape.

Habitat.—Baron Loch, near Peebles (D. R.); Loch Alsh, 1½–4½ faths., Mr. T. Scott (G. S. B.); Hairmyres, near East Kilbride; Moor tarns near Glenluce, Wigtonshire; Broomley Lough, Northumberland; Loch Aber, Kirkcudbrightshire (A. M. N.).

Distribution.—Norway (G. O. Sars, *in litt.*); Russia (Fischer).

6. *Candona kingsleii*, Brady and Robertson.

(Plate ix., figs. 19–22; Plate xiii., fig. 19.)

1785 ? *Cypris detecta*, Müller, Entomostraca, p. 49. Tab. iii., figs. 1–3.
1870. *Candona kingsleii*, Brady and Robertson, Ann. and Mag. Nat. Hist., Ser. iv., vol. vi., p. 17, pl. ix., figs. 9–12.

Shell of the female, seen from the side, sub-reniform, slightly depressed in front; greatest height situated near the middle, and equal to half the length; extremities well rounded, the anterior narrower than the posterior; superior margin boldly arched; inferior rather deeply sinuated in the middle; seen from above, ovate; greatest width situated in the middle, and rather less than the height; pointed in front, narrowly rounded behind. The shell of the male is more deeply sinuated ventrally; the dorsal margin is more boldly arched than in the female, and is slightly excavated towards the front; seen from above, the outline is more compressed. Shell thin, fragile, and colourless; the limbs of the animal distinctly perceptible through. The antennules are stout, the joints all short, and nearly equal, the last two scarcely twice as long as broad; setæ short and stout; terminal setæ of postabdomen stout and rather short, almost

falcate. The last two joints of the mandible palp are extremely long and slender. Length, ·9 mm.

This species is widely distributed in the East Anglian district, where we have found it as follows: Barton, Horsey, Hickling, Wroxham, and Ormesby Broads, Breydon Water, Dyke at Whittlesea, and in the river Nene at Peterborough (G. S. B. and D. R.). In Scotland it has been found in the Islands of Lewis and Cumbrae; in Loch Lomond; Loch Echinlinesh, near Dumfries; St. Jerman Loch and Possil Marsh, near Glasgow; Little Loch, near Melston; in Govan Colliery Dam; at Hairmyres, near East Kilbride; in the Isle of Skye. Also in a pond by the Albert Memorial, Hyde Park, London (D. R.); on the Cardiff Moors, and in a pond at Sophia Gardens, Cardiff (Mrs. Robertson); Whitefield Loch and moor tarns near Glenluce, Wigtonshire; Lochaber Loch, Kirkcudbrightshire (A. M. N.); Osmere, Shropshire (G. S. B.)

We refer doubtfully to *Cypris detecta* (Müller), as a synonym of the present species; but the specimen named *C. detecta* by Dr. Baird, and now preserved in the British Museum, certainly is not *Candona kingsleii*, neither does it seem to us to agree altogether with Müller's description of *C. detecta*.

7. *Candona fabæformis* (Fischer).

(Plate IX., figs. 1–4.)

1851. *Cypris fabæformis*, Fischer, Ueber das Genus Cypris, p. 146, pl. iii., figs. 6–16 ♀ ♂.
1853. *Candona fabæformis*, Lilljeborg, De Crust. ex ord. tribus, p. 207 ♀ ♂.
1870. *Candona diaphana*, Brady and Robertson, Ann. and Mag. Nat. Hist., ser. IV., vol. vi., pl. v., figs. 1–3 ♀.
1870. (?) *Candona hyalina*, iidem, ibidem, p. 18, pl. ix., figs. 5–8, and pl. v., figs. 4–11.

Male. Shell elongated, reniform; seen from the side, the outline is reniform, somewhat depressed in front; greatest height in the middle, and equal to less than half the length; extremities boldly rounded; dorsal margin evenly arched; ventral deeply sinuated rather in front of the middle. Seen from above, elongated, subovate, thrice as long as broad, greatest width in the middle; extremities acuminate. End view ovate, pointed below, rounded above. Shell thin and delicate, pellucid, with yellowish patches; the posterior portion of the valves marked with three or four long crescentic lines, which correspond in position with the coils of spermatic tubes, and run in a concentric manner parallel with the posterior margin of the shell. Antennules slender, the last two joints three or four times as long as broad; setæ long and slender. Post-abdominal rami slender, the two terminal setæ slender and gently curved, the longer of the two more than half as long as the ramus; the marginal seta short, and about one-third the length of the ramus distant from its apex. Length of the shell, 1·25 mm.

Female. Shell, seen from the side, elongated, sub-reniform; greatest height situated behind the middle, and equal to less than half the length; obtusely and evenly rounded in front, obliquely behind; superior margin highest at the posterior third, at that point distinctly angled, and thence sloping almost in a right line and with a very gentle declivity forwards, very steeply and with a slightly concave curve backwards; inferior margin gently sinuated. Seen from above, compressed, tapering equally and rather suddenly to the extremities, which are pointed; sides sub-parallel; width scarcely equalling one-third of the length. The hinge-margin of the left valve is suddenly produced towards each extremity into very conspicuously overlapping curves, the posterior being much larger than the anterior. Length, 1 mm.

The characters of the form described (*loc. cit.*), under the specific name *hyalina*, are perhaps insufficient: the structure ascribed to the "mucous gland" of the male was possibly founded on an erroneous interpretation of a distorted specimen (figs. 5, 6); so that until more perfect information on these matters is attainable, we prefer to regard the specimens previously called *hyalina* as belonging to *C. fabæformis*.

This species has been found as follows:—Craigengam Tarn, Cumbrae; Hairmyres Quarry, near East Kilbride; Lameston Quarries, Ayrshire; Ballagarey Meadow, Isle of Man (D. R.): ditches on Cardiff Moor (Mrs. Robertson): Cooly Barma Lough, Ireland; River Nene at Peterborough, and Ormesby Broad, Norfolk (G. S. B. and D. R.); pond near Taymouth Castle and Crosslea, near Paisley, Mr. T. Scott (G. S. B.).

Distribution.—Sweden (Lilljeborg); Russia (Fischer); France (Moniez).

8. *Candona acuminata* (Fischer).

(Plate ix., figs. 9, 10; Plate x., figs. 5, 6.)

1851. *Cypris acuminata*, S. Fischer, Ueber das Genus Cypris, p. 148, pl. iv., figs. 12–16.
1854. *Cypris acuminata*, Zenker, Monographie der Ostracoden (Archiv für Naturgesch.), p. 74, pl. ii. D.

Shell, seen from the side, sub-cuneate, somewhat arcuate; greatest height behind the middle, not equal to half the length; anterior extremity widely and very evenly rounded, point of greatest prominence central; posterior extremity narrow, not half the height of anterior, sub-truncate, or bluntly rounded; dorsal margin gradually and arcuately rising at first, and from behind the eye the rise is still continued, but here only very slightly until the point of greatest height is reached behind the middle, thence it rapidly descends with slight arcuation to the narrow posterior extremity; the ventral margin very irregular, convex at its commencement in front, then deeply concave, then behind the middle it is

convex (here forming the greatest height), and just before its termination there is again a slight sinuosity. Seen from above, the form is a long ovate; greatest breadth central, scarcely exceeding one-third the length; sides evenly convex, and the extremities equal and not produced. Surface of valves white, smooth, polished, their edges beset with fine hairs. Length, 1·2 mm.

For the Norwegian specimens described above, and figured in Plate x., figs. 5, 6, we are indebted to the kindness of Prof. G. O. Sars. In Britain it is a rare species, the only localities known to us being Hickling Broad, Norfolk (G. S. B. and D. R.): Loch Earn Head; a mill-dam at Wick, Caithness; Killmuir dam, Renfrewshire (D. R.); and Tarbert, Loch Fyne, Mr. T. Scott (G. S. B.). The figures given in Plate IX., figs. 9, 10, were taken from British specimens, which we at first supposed to belong to a distinct species, but now refer without doubt to *C. acuminata.*

Distribution.—Norway (G. O. Sars!); Germany (Zenker); Hungary (Orley); Russia (Fischer).

Zenker figures as the male of *C. acuminata* (Pl. I., fig. 23, *vide* p. 75), a form which is not unlike our *C. rostrata* but more elongated, less high in proportion to its length; and there can be little doubt that the *C. pellucida*, Fischer (p. 149, Pl. v., figs. 1–4), but not the *C. pellucida*, Koch, is the same form.

9. *Candona euplectella*, Robertson, M. S.

(Plate IX., figs. 7, 8, 8*a*.)

1880. *Candona euplectella,* Robertson, Fresh and Brackish Water Ostracoda of Clydesdale, &c., p. 23 (not described).

Shell very tumid, nearly equal in height and width throughout. Seen from the side, the outline is sub-quadrate or sub-reniform, height equal to half the length; extremities equal and well rounded; dorsal margin straight; ventral very slightly sinuated. Seen from above, broadly ovate, very little wider behind than in front, scarcely twice as long as broad, extremities broadly rounded, sides sub-parallel. End view nearly circular. The shell surface is beautifully sculptured with a close reticulated pattern, like the cells of a honeycomb, and bears also small scattered tubercles, surmounted by very long, fine, stiff hairs. The polygonal hollows are, in fact, filled up at distant intervals with solid shell structure, forming bosses, from the summits of which spring single hairs. The setæ of the antennules are not plumose; the limbs are small and slender, and have long slender terminal claws. The few specimens which we have dissected were all males, and probably, as the shape is alike in all cases, the female has yet to be discovered. Length, ·75 mm.

Habitat.—This species has been found in Callum's Tarn, Isle of Bute; Little Cumbrae; at Lochmaben, in the Year Blind and Broomhill Lochs; and Black Loch, near Oban (D. R.); in pools near Port Glasgow, Mr. T. Scott (G. S. B.).

Specimens of *Candona euplectella*, in fine condition, and exhibiting in perfect order the reticulated surface, tubercles and stiff hairs, excel in beauty all other European freshwater Ostracoda.

10. *Candona* (?) *parabolica* (Koch).

(Plate xiii., figs. 28–30.)

1837. *Cypris parabolica*, Koch, Deutschlands Crustaceen, &c., H. xi. 4.

Shell elongated, large, long, smooth, polished, higher before than behind; dorsal margin not arched; ventral margin slightly compressed; the anterior and posterior margins with a very fine fringe of hairs, which are, however, only visible in water. Seen from above, the shell is small, oval, and pointed before and behind; pale ochreous yellow, on the back shaded darker; on the front edge a small whitish band, on this a darker ochreous yellow, and behind a lighter, rather transparent line. Sometimes the shell is green, or spotted with green, the colour arising from a transparent deposit on the surface of the shell. It cannot swim; its movements in water are only creeping; but it can easily ascend plants or rough surfaces.

Rather rare in ditches of Germany.

We give in Plate xiii. copies (uncoloured) of Koch's figures of this species, the only one of the Ostracoda described by him which we have been unable to assign to recognized forms. The description is slightly abridged from Koch's.

Genus XIII.—Ilyocypris, nov. gen.

(ἰλυς, mud.)

[Type, *Ilyocypris gibba* (Ramdohr).]

Shell oblong, with a transverse median depression, coarsely punctate and tuberculate. Antennal setæ non-plumose, few; reaching a little beyond the apex of the terminal claws. Mandible-palp 4-jointed, with a 5-(?)setose branchial appendage. First pair of maxillæ composed of four segments, and a large branchial appendage bearing numerous terminal and about five reflexed basal setæ. Second pair of maxillæ consisting of a conical lobe, which bears numerous short marginal setæ, at the apex four stout plumose setæ, and at the base an appendage of four radiating

plumose filaments and a bi-articulate process bearing three apical setæ, one of which is plumose. The penultimate joint of the second foot has two marginal setæ; the last joint three long apical setæ, but no claw. Caudal rami ending in two long and equal claws, and one very short seta, marginal seta long, and attached near the middle of the ramus.

Ilyocypris gibba (Ramdohr).

(Plate XXII., figs. 1–5.)

1820. (?) *Monoculus puber*, Jurine, Hist. des Monocles, p. 171, pl. xviii., figs. 1, 2 (*non C. puber*, Müller).
1820. *Monoculus bistrigatus*, idem, ibidem, p. 177, pl. xix., figs. 12, 13 (*junior*).
1838. *Cypris biplicata*, Koch, Deutschlands Crustaceen, H. 21, pl. xvi.
1844. *Cypris bistrigata*, Zaddach, Syn. Crust. Pruss. Prodr., p. 37.
1847. *Cypris sinuata*, Fischer, Mem. de l'Acad des Sci. de St. Petersbourg, vol. VI., p. 35, pl. x., fig. 4.
1851. *Cypris biplicata*, Fischer, Ueber das Genus Cypris, p. 150, pl. v., figs. 5–8.
1853. *Cypris bistrigata*, Lilljeborg, De Crust. ex ord. tribus, p. 122, pl. xi., figs. 17, 18.
1868. *Cypris gibba*, Brady, Mon. rec. Brit. Ostrac., p. 369, pl. xxiv., figs. 47–54; pl. xxxvi., fig. 2.
1874. *Cypris gibba*, Brady, Crosskey, and Robertson, Post-tert. Entom., p. 127, pl. xv., figs. 5, 6.

Common in the British Islands.

Distribution.—Sweden (Lilljeborg!); Prussia (Zaddach! and Koch); Switzerland (Jurine); Hungary (Orley); Russia (Fischer); France (Moniez!).

Fossil.—Scotland; England.

Genus XIV.—Pontocypris, G. O. Sars.

[Type, *P. mytiloides* (Norman).]

1. *Pontocypris mytiloides* (Norman).

Synonyms.—Cythere avena, Norman; *P. serrulata*, G. O. Sars.

1858. (?) *Bairdia dactylus* and *var. punctata*, Egger, Die Ostracoden der Miocän-Schichten bei Ortenburg, p. 7, pl. i., figs. 3, 4.
1868. *Pontocypris mytiloides*, Brady, Mon. rec. Brit. Ostrac., p. 385, pl. xxv., figs. 26–30; pl. xxxvii., fig. 1.
1874. *Pontocypris mytiloides*, Brady, Crosskey, and Robertson, Post-tert. Entom., p. 136, pl. xv., figs. 7, 8.

A widely-distributed and common species, occurring all round the British coasts, from low-water mark downwards, but most abundantly in the laminarian zone.

Distribution.—Christiania and Flekkefiord, Norway, 3–6 fath. (G. O. Sars); Oster Fiord and Lervig Bay, Norway (A. M. N.); off Capri, Bay of Naples, 40 fath. (A. M. N.); Fosse de Cape Breton, 135 fath. (G. S. B.).

Fossil.—Scotland, Norway, Calabria (?).

2. *Pontocypris hispida*, G. O. Sars.

1865. *Pontocypris hispida*, G. O. Sars, Oversigt af Norges marine Ostracoder, p. 16.
1868. *Pontocypris hispida*, Norman, Last Report Dredging Shetland Isles (Brit. Assoc. Rep.), p. 289.
(Not *Pontocypris hispida*, Brady and Robertson, Ann. and Mag. Nat. Hist., ser. iv., vol. ix. (1872), p. 61.)

Shell, seen from the side, subtriangular, highest in front, height equal to nearly half the length; anterior extremely well rounded, posterior tapered and sub-acute; dorsal margin strongly arched, highest at the anterior third, whence it slopes with a gentle curve to the front, and more steeply towards the posterior extremity; inferior margin very slightly sinuated in front of the middle, and upcurved at the hinder end. Seen from above, the outline is ovate, widest near the front, nearly three times as long as broad; extremities sub-acute, tapered rather abruptly in front, more gradually behind. Valves smooth, or very minutely punctate, and clothed more or less thickly with very fine adpressed hairs. Colour, yellowish. Terminal claw of the first pair of feet very long and slender, exceeding the united lengths of the preceding four joints, and strongly curved at the apex. Terminal setæ of the caudal rami nearly equal. "Copulatory organs of the male elongated, almost linear, and obtusely rounded at the apex. Eyes wanting." Length, ·8 mm.

The only undoubted British examples of this species were dredged in Birturbuy Bay, Ireland (G. S. B. and D. R.); and Unst Haaf, Shetland (A. M. N.).

Distribution.—Professor G. O. Sars took it in Christianiafiord, in a depth of 30–50 fathoms, on a clay bottom; Lervig Bay, Stordoen, Norway (A. M. N.).

The specimens referred by Messrs. Brady and Robertson (*loc. cit.*) to *P. hispida* belong really to *P. mytiloides*. We now admit the two species as quite distinct.

3. *Pontocypris acupunctata*, Brady.

1868. *Pontocypris acupunctata*, Brady, Mon. rec. Brit. Ostrac., p. 386, pl. xxiv., figs. 53–56.
1874. *Pontocypris acupunctata*, Brady, Crosskey, and Robertson, Post-tert. Entom., p. 137, pl. ii., figs. 18, 19.

This is a very rare species. The only additional localities since the publication of the monograph of 1868, are St. Magnus Bay, Shetland (A. M. N.); Budle Bay, Northumberland; and off Marsden, Durham, 10 fathoms (G. S. B.).

Distribution.—Batalden, near Floro, Norway (A. M. N.).

Fossil.—Scotland (Oban).

4. *Pontocypris trigonella*, G. O. Sars.

(Plate XXII., figs. 18–25; Plate XXIII., fig. 6.)

1868. *Pontocypris trigonella*, Brady, Mon. rec. Brit. Ostrac., p. 387, pl. xxv., figs. 31–34; pl. xxxviii., fig. 3.
1874. *Pontocypris trigonella*, Brady, Crosskey, and Robertson, Post-tert. Entom., p. 137, pl. xvi., figs. 26–28.
1880. *Pontocypris trigonella*, Seguenza, Le formazioni terziarie nelle provincia di Reggio, pp. 288 and 362.
1880. *Pontocypris trigonella*, Brady, Report "Challenger," Ostrac., p. 36, pl. xv., figs. 4 *a–d*.
1883. *Pontocypris trigonella*, Seguenza, Il Quaternario di Rizzolo, Gli Ostracodi, p. 4.
1885. *Pontocypris trigonella*, Carus. Prod. Faunæ Mediterraneæ, p. 313.

This species is found in moderate abundance all round the coasts of the British Islands, ranging from low water-mark to 30 fathoms. It is commonest and best developed in the laminarian zone; but we have only one record of its occurrence between tide-marks, at Rockport, Co. Down, where it was taken by the late Dr. Malcomson.

Distribution.—Norway to Lofoten Islands (G. O. Sars); Haakelsund, Kors Fiord, 3–10 fath.; and Lervig Bay, Stordoen, 3–25 fath., Norway (A. M. N.); Messina and Syra (G. S. B.), Naples (A. M. N.); Cape Verde Islands and the Bermudas (G. S. B.).

Fossil.—Scotland, Calabria, Sicily.

Genus XV.—Anchistrocheles, nov. gen.

(ἄγκιστρον, a hook; χηλὴ, a claw.)

[Type, *Anchistrochles fumata*, G. S. Brady, M.S.]

Shell much compressed, reniform; seen laterally, the anterior margin is very obliquely truncated, the obliquity looking downwards; dorsal margin arched; ventral very deeply sinuated; antennules seven-jointed, the first joint very much longer than all the rest put together, bearing a lash of about ten long setæ, which arise from the last two joints, the rest being bare except that there is one seta near the apex of the first joint. Antennæ five-jointed, ending in a very long claw, which is much longer than the length of the entire limb, and is bent sharply at the extremity so as to form a minute hook; at the sides of the claw are two setæ of rather more than half its length: the penultimate joint has a brush of three very small setæ at the apex, and the second joint bears two setæ of moderate length. The mandible is slender, and rather feebly dentated at the apex; palp four-jointed, and provided with a small trisetose branchial appendage. First maxilla four-segmented, and having a setiferous branchial plate of moderate size. First foot four-jointed, bearing a hooked claw like that of the antenna, and giving attachment on the first joint to a one-jointed setiferous appendage, which possibly represents the second maxilla. Second foot four-jointed, and having a very long, curved, apical claw. Caudal rami rudimentary, bearing three setæ, one of which is very short, the others long and nearly equal. Copulative organ of the male large and complex.

This description is taken from specimens of an undescribed species collected by Dr. H. B. Brady, F.R.S., in the Fiji Islands. The Fijian shell, however, in its very peculiar form so closely resembles the British species, hitherto provisionally placed under *Cythere*, that we have no hesitation in referring both species to the same genus.

1. *Anchistrocheles acerosa* (Brady).

1868. *Cythere acerosa*, Brady, Mon. rec. Brit. Ostrac., p. 419, pl. xxxi., figs. 55–58.

No living specimens of this animal have yet been seen. It has been found, but always very sparingly, in dredgings from Dungeness Bay and off the Eddystone (G. S. B.); by Dr. Norman at Shetland and Plymouth; in dredgings by Mr. E. C. Davison off North of Scotland; and by Mr. Malcomson in the Irish Sea.

Distribution.—River Scheldt, Holland (G. S. B.).

Genus XVI.—Argilloecia, G. O. Sars.

[Type, *Argilloecia cylindrica*, G. O. Sars.]

Valves smooth, elongated, moderately robust, scarcely higher in front than behind, more or less angulated at the union of the posterior and inferior margins; antennules robust, five-jointed, first joint very large and stout, the rest beset on the lower margins with strong spines, and on the upper margins, especially in the male, with long setæ; antennæ short and thick, otherwise like those of *Pontocypris;* setæ of the antepenultimate joint in the female short, in the male very long, and reaching much beyond the terminal claws. Mandibles almost as in *Pontocypris*, the palp, however, having only three or four setæ ("one," Sars) in place of a branchial appendage. Palp of the second pair of jaws indistinctly three-jointed, bearing several terminal setæ (ending in a single claw, Sars). First pair of feet strong, terminating in two nearly equal claws; second pair unlike the first, and almost like those of *Pontocypris;* last joint very short, and bearing about three spines, of which one is very long and curved. Post-abdominal rami short, attenuated towards the apices, and with very small terminal claws. Eye wanting.

1. *Argilloecia cylindrica*, G. O. Sars.

(Plate x., figs. 28, 29.)

1865. *Argilloecia cylindrica*, G. O. Sars, Oversigt af Norges marine Ostracoder, p. 18.
1865. *Cytherideis oryza*, Brady, Trans. Zool. Soc., vol. v., p. 368, pl. lviii., figs. 2 *a–b*.
1868. *Pontocypris* (?) *angusta*, Brady, Mon. rec. Brit. Ostrac., p. 387, pl. xxxiv., figs. 43, 44.
1869. *Argilloecia angusta*, Brady and Robertson, Ann. and Mag. Nat. Hist., ser. iv., vol. iii., p. 11.
1874. *Argilloecia cylindrica*, Brady, Crosskey, and Robertson, Post-tert. Entom., p. 132, pl. xvi., figs. 29–31.
1885. *Argilloecia angusta*, Carus, Prod. Faunæ Mediterraneæ, p. 315.

The specimens from Birterbuy Bay, described in the "Monograph" of 1868 under the name *Pontocypris* (?) *angusta*, belong to this species.

Additional localities.—In dredgings from Loch Long, the Firth of Clyde, off Greenock and Largs, Firth of Forth, in the river Ouse, off the Eddystone Lighthouse, and off St. Mary's, Scilly (G. S. B. and D. R.); Shetland; off Tarbert, Loch Fyne, 25 fath.; Salcombe, Devon; Valentia and Roundstone, Ireland (A. M. N.); Irish Sea and Belfast Lough (Malcomson); off Seaham and Marsden, Durham coast (G. S. B.).

Distribution.—Christiania Fiord, 30–50 fath. (G. O. Sars); Oster Fiord, 375 fath.; off Sartoro, Bergen Fiord, 15–40 fath.; Lervig Bay, 10–25 fath.; Stocksund, 80–100 fath.; off Dröbak, 30–100 fath.; all in Norway. Fosse de Cape Breton, Bay of Biscay, 180–200 fath. (A. M. N.); Hammerfest Harbour; River Scheldt, Holland; Mediterranean; Tenedos and Besika Bay (G. S. B.).

Fossil.—Scotland.

Fam. II.—BAIRDIIDÆ.

Genus I.—*Bairdia*, M'Coy.

[Type, *Bairdia curta*, M'Coy.]

Shell tumid; seen from the side triangular or sub-quadrate, anterior extremity broadly rounded, posterior more or less produced. Valves moderately dense, calcareous, often clothed with stiff hairs, extremities often toothed; left valve much larger than the right. Antennules slender; last four joints distinct, and bearing numerous long, slender setæ. Antennæ elongated, apical portion attenuated and bearing two strong terminal claws. Biting portion of the mandible having five long and strongly aculeated teeth; palp pilose and rather narrow, bearing a branchial appendage composed of three setæ, the foremost of which is very long. Segments of the maxillæ long and narrow, palp exactly like these in form and size, one-jointed; branchial lamina large, and having at the base a posterior dilatation, broadly rounded, and clothed with very slender non-ciliated setæ; terminal portion rounded, ovate, bordered with strong plumose setæ. Feet successively larger; similar in build, penultimate joint narrow and elongated; a large, oblong-triangular branchial lamina affixed to the first pair. Caudal rami not large, linear, divergent, bearing three strong apical setiform claws, the middle one elongated; marginal setæ four.

In this generic definition we follow Professor G. O. Sars.

1. *Bairdia inflata*, Norman.

1865. *Bairdia obliquata*, G. O. Sars, Oversigt af Norges marine Ostracoder, p. 24.
1868. *Bairdia inflata*, Brady, Mon. rec. Brit. Ostrac., p. 388, pl. xxvii., figs. 9–17; pl. xxxviii., fig. 5.
1874. *Bairdia inflata*, Brady, Crosskey, and Robertson, Post-tert. Entom., p. 139, pl. xv., figs. 1–4.

Additional localities.—Dredged off Red Cliff, Yorkshire (G. S. B. and D. R.); Clew Bay, Ireland (A. M. N.); Irish Channel, 15–62 fath.; Belfast Lough, 10 fath. (Malcomson.)

Distribution.—Very rare; Oxfiord, Finmark (G. O. Sars); off Sartoro, Bergen Fiord, 15–40 fath.; Kors Fiord, 180 fath.; off Midso Lighthouse, Hardanger Fiord, 50–100 fath. (A. M. N.); Fosse de Cap Breton, 45 fath.; Marquis de Folin (G. S. B.).

Fossil.—Scotland (Oban).

2. *Bairdia acanthigera*, Brady.

1868. *Bairdia acanthigera*, Brady, Mon. rec. Brit. Ostrac., p. 390, pl. xxvii., figs. 18–21.
1880. *Bairdia acanthigera*, Brady, Report, "Challenger," Ostrac., p. 61, pl. ix., figs. 4*a–c*.
1883. *Bairdia acanthigera*, (?) Seguenza, Il Quaternario di Rizzolo II. Gli Ostracodi, p. 17.

The only known British localities are those recorded in the "Monograph," namely, Devonshire and the Channel Islands.

Distribution.—Off St. Vincent, Cape Verde Islands, 1070 and 1150 fath., "Challenger" Exped. (G. S. B.).

Fossil.—(?) Rizzolo, Sicily.

3. *Bairdia subcircinata*, n. sp.

1880. *Bairdia formosa*, Brady, Report, "Challenger," Ostrac., p. 52, pl. x., figs. 1 *a–c*.
(*Not* 1868, *B. formosa*, Brady, Ann. and Mag. Nat. Hist., ser. iv., vol. ii., p. 221, pl. xiv., figs. 5–7.)

Shell, as seen from the side, triangular, all the angles broadly rounded off; height greatest in the middle, and equal to three-fourths of the length; the dorsal margin is excessively arched, and somewhat gibbous in the middle; the ventral straight or rather convex; anterior extremity broadly rounded, posterior narrower, slightly produced below the middle. Seen from above the outline is very broadly ovate, the greatest width being situated in the middle, and equal to more than half the length; extremities obtuse, sub-mucronate. The end view is broadly ovate, the height considerably greater than the width. In well-developed adult specimens the surface is slightly punctate, and is beset with numerous little tubercular or papilliform eminences; the left valve bears in front and at the infero-posteal angle a series of five to seven spines; the right valve is fringed along its anterior margin with a considerable number—twelve or more—of small blunt teeth. Young specimens have the shell quite smooth and destitute of marginal teeth. Length, 1·55 mm.

In the report on the "Challenger" Ostracoda, the specimens there referred to *Bairdia formosa* were noted as differing from the Mediterranean type; but after an examination of the more recent dredgings of the "Talisman" (see Appendix)

we no longer doubt that the two forms are specifically distinct, and we propose for the Atlantic species the name *subcircinata.*

The most important distinctive characters are, that both extremities are spinous, the left valve having in front a series of about seven marginal spines, and the right a closely-set row of short blunt teeth. At the posterior extremity the upward slope of the ventral margin is beset with numerous small spines (usually smaller than represented in the "Challenger," *loc. cit.*, plate x., fig. 1 *b*); and in the living condition the shell is clothed with strong dark-brown hairs, and marked with distant, rather coarse, circular puncta; posterior margin not at all beaked.

Distribution.—North Atlantic, lat. 38° 11′ N., long. 27° 9′ W., 900 fath.; South Atlantic, lat. 8° 37′ S., long. 34° 28′ W., 675 fath.; and off North Brazil, lat. 9° 5′ S., long. 34° 49′ W., 350 fath.; South Pacific, one or two doubtful examples, lat. 5° 26′ S., long. 133° 19′ E., 580 fath.; all "Challenger" Exped. (G. S. B.); North Atlantic, lat. 56° 1′ N., long. 34° 42′ W.; "Valorous" Exped., 1875, Stat. 13 (A. M. N.).

4. *Bairdia angulata*, Brady.

1870. *Bairdia angulata*, Brady, Les Fonds de la Mer., vol. i., p. 199, pl. xxvii., figs. 11, 12.
1880. *Bairdia angulata*, Brady, Report, "Challenger," Ostracoda., p. 59, pl. xi., figs. 5 *a–d*.

Shell oblong, compressed; seen from the side sub-reniform, scarcely twice as long as high; extremities well and evenly rounded, the anterior bearing about the middle few (four or five) short, broad teeth; the posterior armed *below* the middle with six or eight nearly similar teeth; dorsal margin very slightly arched; ventral straight, except that near the front at its junction with the anterior border, it is produced downwards into a conspicuous angular prominence. Seen from above, the outline is about thrice as long as broad, compressed, with parallel sides and tapering acuminate extremities. End view ovate, compressed; width scarcely equal to half the height. Surface of valves smooth or finely punctate. Length, ·9 mm.

Distribution.—Dredged by "Challenger," off the Azores, lat. 38° 37′ N., long. 28° 30′ W., 450 fath.; South Atlantic, lat. 47° 48′ S., long. 74° 48′ W., 120 fath.; and in Torres Straits, 155 fath. The original specimens were taken at Halt Bay, in the Straits of Magellan (G. S. B.).

5. *Bairdia victrix*, Brady.

1869. *Bairdia victrix*, Brady, Les Fonds de la Mer., vol. i., p. 152, pl. xviii., figs. 17, 18.
1880. *Bairdia victrix*, Brady, Report, "Challenger," Ostracoda, pl. 56, p. x., figs. 5*a–d*.

Shell tumid, gibbous; seen from the side sub-triangular, height equal to rather more than two-thirds of the length; anterior extremity rounded; posterior obliquely truncate and produced into a prominent obtuse beak; dorsal margin very boldly arched; ventral more or less convex, and often irregularly sinuous towards the posterior extremity; the margins of the right valve are often beset at the two extremities with numerous short obtuse teeth. Seen from above, the outline is broadly ovate, more than twice as long as broad, widest in the middle; anterior extremity sub-acuminate, posterior broadly mucronate. End view ovate, widest below, height almost one-third greater than the width. Surface of the shell smooth, sometimes sparingly punctate, and (especially towards the hinder end) having a few scattered, rigid hairs. Length, 1·6 mm.

Distribution.—Dredged by "Challenger" in North Atlantic, in the neighbourhood of the Azores, lat. 38° 11′ N., long. 27° 9′ W., 900 fath.; and lat. 38° 37′ N., long. 28° 30′ W., 450 fath. Also off North Brazil, 350 to 675 fath.; off Kerguelen Island 120 fath.; off Sydney, Australia, 410 fath.; and to the north of Tristan d'Acunha, 1425 fath. The first-described specimens were from Colon-Aspinwall, and it has also been taken at Cuba (G. S. B.); North Atlantic, lat. 56° 1′ N., long. 34° 42′ W., 690 fath., "Valorous" Exped., 1875. Stat. 13 (A. M. N.).

6. *Bairdia crosskeiana*, Brady.

(Plate x., figs. 3, 4.)

1865. *Bairdia crosskeiana*, Brady, Trans. Zool. Soc., vol. v., p. 366, pl. lvii., figs. 10 *a–d*.
1880. *Bairdia crosskeiana*, Brady, Report "Challenger" Ostracoda, p. 58, pl. ix., figs. 3 *a–c*.
1884. *Bairdia crosskeiana*, Seguenza, Il Quaternario di Rizzolo II. Gli Ostracodi, p. 15.
1885. *Bairdia crosskeiana*, Carus, Prodr. Faunæ Mediterraneæ, p. 316.

Shell elongated, compressed, greatest height equal to about half the length, and situated near the middle; seen laterally, the outline is sub-ovate or sub-triangular, wider in front than behind; anterior extremity obliquely rounded, angulated at its junction with the dorsum, lower angle obliterated and forming a

wide curve continuous with the ventral margin; posterior narrow and tapered, sub-acute and more or less squamously dentated below; dorsal margin well arched, slightly sinuated in front; ventral nearly straight. Seen from above the outline is lozenge-shaped, more than twice as long as broad; near the front tapering rather abruptly forwards, gradually and with a gentle curve towards the posterior extremity; anterior extremity obtuse; posterior pointed; surface smooth, closely set with minute punctations. Length, 1·3 mm.

Distribution.—Fosse de Cap Breton; two miles from the mouth of the Adour, Marquis de Folin (G. S. B); Fosse de Cap Breton, 30–60 fath., and 180–200 fath. (A. M. N.); Tongatabu; Nares' Harbour, Admiralty Islands, 16 fath.; Honolulu, 40 fath., "Challenger" dredgings (G. S. B.); Messina (Seguenza).

Fossil.—Sicily (Seguenza).

The southern form of this species, as shown in the "Challenger" specimens, is somewhat more slender, and the outline, as seen from above, is more distinctly angular and hastate.

7. *Bairdia obtusata*, G. O. Sars.

1868. *Bairdia obtusata*, Brady, Mon. rec. Brit. Ostrac., p. 390, pl. xxxiv., figs. 22–25.

Additional locality.—Irish Channel, 60 fath. (Malcomson).

Distribution.—Flekkefiord, West Norway, 80–90 fath. (G. O. Sars); Solems Fiord by Floro, 30–60 fath.; off Midso Lighthouse, Hardanger Fiord, 50–210 fath.; Stoksund, 126 fath., all on the West Norwegian Coast (A. M. N.).

Fossil.—Calabria (Seguenza).

8. *Bairdia complanata*, Brady.

(Plate xiii., figs. 20–26.)

1868. *Bairdia complanata*, Brady, Mon. rec. Brit. Ostrac., p. 390, pl. xxxiv., figs. 1–4.
1880. *Bairdia complanata*, Seguenza Le format. terz. Reggio, p. 288 ("*var. sinuata*").
1883. *Bairdia complanata*, Seguenza, Il Quaternario di Rizzolo II., Gli Ostracodi, p. 17 ("*var. sinuata*").
1885. *Bairdia complanata*, Carus Prod. Faunæ Mediterraneæ, p. 317.

Additional localities.—Five to eight miles east of Balta, Shetland, 40–50 fath.; Loch Fyne (A. M. N.).

Distribution.—Abundant in certain localities on West Norway coast; south side of Kors Fiord, 180 fath.; off Sartoro Bergen Fiord, 15–40 fath.; off Midso Lighthouse, Hardanger Fiord, 50–100 fath. (A. M. N.), *var. sinuata*, Messina (Seguenza).

Fossil.—*Var. sinuata*, Rizzolo, Sicily, and Calabria (Seguenza).

Prof. G. O. Sars has recently suggested* that *Bairdia complanata*, and *B. obtusata* probably belong to the genus *Bythocypris*. The anatomy of *Bythocypris* is only very imperfectly known, the drawings given in the Report of the "Challenger" Expedition being founded on an examination of one or two mutilated specimens; but so far as we can at present ascertain, *Bairdia complanata* seems to be intermediate in its characters between the two genera; the caudal rami, antennules, and mandibles agreeing pretty closely with those of *Bairdia*, while the shell and antennæ approach those of *Bythocypris*. For the present it seems best to leave the species in the genus *Bairdia*.

Genus II.—Macrocypris, Brady.

[Type, *Macrocypris minna* (Baird).]

1. *Macrocypris minna* (Baird).

1868. *Macrocypris minna*, Brady, Mon. rec. Brit Ostrac., p. 392, pl. xxvii., figs. 5–8; pl. xxxviii., fig. 4.
1880. *Macrocypris minna*, Seguenza, Formaz. terziarie nella provincia di Reggio, p. 191.
1883. (?) *Macrocypris minna*, idem, Il Quaternario di Rizzolo II. Gli Ostracodi, p. 10.

The only British locality of this species is Shetland, where a single specimen was dredged by M'Andrew forty years ago, and a second by A. M. N. on the Outer Haaf, in 1861.

Distribution.—Christiania Fiord, 20–50 fath., and thence to the Lofoten Islands (G. O. Sars); Dröbak, Christiania Fiord, 30–100 fath.; Oster Fiord, north of Bergen, 50–375 fath.; Lervig, Stordoen, 25 fath. (A. M. N.); Bay of Biscay, Marquis de Folin (G. S. B.).

Fossil.—Calabria; (?) Rizzolo, Sicily (Seguenza).

2. *Macrocypris angusta* (G. O. Sars).

(Plate ix., figs. 17, 18.)

1865. *Bairdia angusta*, G. O. Sars, Oversigt af Norges marine Ostracoder, p. 22.

Shell greatly elongated, narrow, and produced at the extremities; seen from the side, both ends are much drawn out, and finally terminate in spine-points, hinder extremity the more produced; greatest height in front of the middle, less than one-third the length; dorsal margin evenly arched, except near the posterior extremity, where there is a slight concavity; ventral margin sinuated in

* Nye Bidrag til Kundskaben om Middelhavets Invertebratfauna, iv., Ostracoda Mediterranea p. 117.

front of the middle, behind this nearly straight with a slight tendency to convexity. Seen from above, greatly elongated, and very narrow; greatest breadth nearly central, a little less than the height, equally attenuated towards the very acute extremities. Surface of valves white, smooth, and polished; a few short, scattered hairs at the extremities. The right valve is somewhat larger than the left, which closes partially within it, especially at the posterior extremity. Length, 2 mm.

Sars thus describes the animal:—"Membra animalis pallide flavescentia. Antennæ quam in *M. minna* magis elongata; superiores longius setiferæ, articulo tertio valde elongato, sequentibus 3 junctis longiore, inferiorum articulus antepenultimus antecedente multo longior, ungues terminales breves et inæquales. Aculei palpo maxillarum 2^{di} paris inhærentes non dentatæ. Pedum primi paris articulus secundus sequentibus duobus junctis, longitudine circiter æqualis, ultimus brevissimus ungue unico perlongo et curvato instructus. Pedum ultimi paris unguis terminalis in margine modo altero dentatus. Rami postabdominales appendices duas sat elongatas, mucroniformes, obsolete biarticulatas ad apicem acuminatam leviter supra curvatas formantes. Organa copulationis maris forma singulari, aviculariis Polyzoum simillima, processibus rostriformibus duobus mobilibus sibique applicantibus instructa."

Distribution.—Frequent in the Christiania Fiord, and abundant near Trondhjem (G. O. Sars); off Midso Lighthouse, Hardanger Fiord, 50–100 fath.; Dröbak, Christiania Fiord, 100 fath. (A. M. N.). Only as yet known in Norway.

This species differs somewhat from the typical *Bairdiæ* in the conformation of the antennules and caudal rami; but we have not at our disposal materials for a complete investigation of its anatomy.

3. *Macrocypris siliquosa*, Brady.

Macrocypris siliquosa, Brady, Les Fonds de la Mer., vol. iv., p. 194, pl. xiv., figs. 1-3.

Shell elongated, compressed; seen from the side, the height is everywhere nearly equal, being about two-fifths of the length; anterior extremity evenly rounded, posterior forming with the dorsal margin a continuous curve, and joining the ventral margin at an acute angle; dorsal margin evenly and very slightly arcuate; ventral almost straight, slightly convex behind the middle; seen from above, the outline is a compressed oval, thrice as long as broad and widest in the middle, only slightly tapered towards the extremities, which are moderately broad. The right valve is larger than the left, overlapping both on the dorsal and ventral margins. Surface perfectly smooth and white. Length, 1·55 mm.

Macrocypris siliquosa.

The types of this species were found by the Marquis de Folin in one of the dredgings of the "Talisman," from a depth of 932 metres, in lat. 23° N., long. 16° 27′ W. (G. S. B.) We have also found a broken fragment of a valve, belonging to the same species, in one of the "Porcupine" dredgings from lat. 56° 11′ N., long. 10° 56′ W., depth 1366 fath. (A. M. N.).

Genus III.—Bythocypris, Brady.

[Type, *Bythocypris bosquetiana* (Brady).]

Shell thin and fragile, smooth, reniform or subreniform; left valve much larger than the right, which it overlaps both on the dorsal and ventral margins. Antennules short and stout, six-jointed, the first two joints very large, the remainder small, and bearing numerous long setæ. Antennæ also short and stout, five-jointed, having no "hyaline-vesicle," the second and fifth joints about twice as long as the rest, scarcely at all tapered towards the apex, and terminating in about six curved setæ, one of which is much stouter than the others. Mandibles armed with numerous strong serrated apical teeth, and furnished with a well-developed four-jointed and setiferous palp, the first joint of which bears a rudimentary branchial appendage, consisting of a single stout seta. One pair of jaws only (?), consisting of four setiferous digits, and a large branchial appendage, which is divided into two portions, the upper portion ovate, and bearing ten setæ, the lower narrow, biarticulate, and provided with five slender setæ. Two pairs (?) of feet, the first having a single curved terminal claw, and about three short marginal setæ; the second rudimentary, consisting of a single small joint, with two stout setæ. Post-abdominal rami of moderate size, curved, and armed at the apex with one long and one short curved seta.

Bythocypris was described by Professor Brady in his "Challenger" Report, to which we refer for further observations of the genus and illustrations of the animal.

The type species, *B. reniformis* (Brady), we are now satisfied is the species described long before (from a young shell) as *Bairdia bosquetiana* (Brady).

Bythocypris bosquetiana (Brady).

(Plate XIV., figs. 34, 35, *junior.*)

1865. *Bairdia bosquetiana*, Brady, New and imperfectly known species of marine Ostracoda, Trans. Zool. Soc., vol. v., p. 364, pl. lvii., figs. 5 *a–c* (*junior*).
1880. *Bythocypris reniformis*, Brady, Rep. "Challenger," Ostracoda, p. 46, pl. v., fig. 1 *a–b*.

Shell reniform; seen laterally, the greatest height is situated in the middle, and equal to more than half the length; extremities rounded, the anterior rather broader than the posterior; ventral margin sinuated in the middle, dorsal boldly and evenly arched. Seen from above, the outline is narrowly ovate, about thrice as long as broad, and widest in the middle, tapering evenly to the extremities, of which the anterior is pointed, and the posterior more obtusely pointed. End view ovate, the width equal to about two-thirds of the height. The left valve is more rounded in contour, and is also much more strongly arched dorsally than the right valve. The hinge-margins overlapping along almost the entire length of the left valve, the lower margin also forms a curved flange, which overlaps the right valve in the middle of the ventral aspect. The shell is thin, smooth, and homogeneous in structure, but marked with irregularly-scattered translucent spots; muscle spots arranged irregularly near the centre of the valves. Length, 1·3 mm. in the "Challenger" specimens; but the Atlantic example is considerably smaller.

Distribution.—Atlantic Ocean, 470 fath.; Commander Dayman's soundings; off Culebra Island, West Indies, 390 fath.; off North Brazil, 350–675 fath.; off Prince Edward's Island, 50–150 fath.; and off Moncœur Island, Bass' Strait, 40 fath.; all from "Challenger" dredgings (G. S. B.).

The reniform contour and very marked overlapping of the one valve over the other on the dorsal margin are points by which this species may be readily distinguished.

[*Goniocypris mitra*, B. and R.—The shell described under this name in the "Annals and Magazine of Natural History" for July 1870 is not an Entomostracan, but the fry of *Anodonta cygnæa*.

The fry of *Anodonta* is described by Dr. Jeffreys in his work on the British Mollusca, vol. i., p. 43].

Fam. III.—DARWINULIDÆ.

Genus Darwinula, Brady and Robertson.*

Polycheles, Brady and Robertson; *Darwinella*, Brady and Robertson (names pre-occupied.)

[Type, *D. stevensoni*, Brady and Robertson.]

1870. *Polycheles*, Brady and Robertson, Ann. and Mag. Nat. Hist., ser. iv., vol. vi., p. 25.
1872. *Darwinella*, Brady and Robertson, Ann. and Mag. Nat. Hist., ser. iv., vol. ix., p. 50.
1874. *Darwinella*, Brady, Crosskey, and Robertson, Post.-tert. Entom., p. 140.
1885. *Darwinella*, Brady and Robertson, Quart. Journ. Geol. Soc.

Shell smooth, thin, and fragile. Carapace oblong, higher behind than in front; lucid spots ten to twelve in number, linear-oblong or wedge-shaped, arranged in a subradiate manner in front of the centre of the valve. Seen from the side, compressed, oblong, subovate. Seen from above, ovate, acuminate in front, obtusely rounded behind. Valves unequal, the right much larger than the left. Antennules very short, six-jointed, and stout, strongly armed with short and stout curved setæ. Antennæ four-jointed, and bearing four or five strong terminal claws; entirely destitute of poison gland or urticating setæ, the place of which is occupied by a single curved seta of moderate length. Mandible broad, truncated at the distal extremity, which is provided with six or seven small spiniform teeth; palp three-jointed, its basal joint very wide and fringed with several curved setæ, bearing also a small lamina, fringed with branchial filaments; second joint long, slender, nearly four times as long as broad, slightly curved and dilated at the distal extremity, where it bears one long and two small setæ; terminal joint more slender, about two-thirds of the length of the foregoing, and bearing at the truncate apex about six slender curved spines. First maxilla divided into four short setiferous segments, and bearing a very large oblong palp, which is fringed with about twenty-four long branchial filaments, and has also four other long setæ at its base. Second maxilla simple, short, and broad, truncate at the apex, and fringed on the distal margin with several slender spine-like hairs, bearing also a large, three-jointed, pediform palp, and an ovate branchial appendage of moderate size. Two pairs of feet of moderate size, five-jointed; second pair much the longest, and having the

* The generic term *Darwinella* having been previously appropriated by Fritz Müller for a genus of horny sponges was withdrawn in favour of *Darwinula*; see T. Rupert Jones, on "the Ostracoda of the Purbeck Formation," Quarterly Journal of the Geological Society, August, 1885.

last joint armed with one long and two small curved setæ; first three joints of nearly equal length; fourth and fifth, respectively, about one-half and one-third as long as the preceding. Abdomen ending in a short conical process. Copulative organs of the male of complex structure, the basal portion (on each side) consisting of a subrhomboidal acuminate lamina, the apical portion of an irregularly-shaped plate produced laterally into an aliform process, and on the distal margin into a short, strong hook. Female probably viviparous.

Darwinula stevensoni, Brady and Robertson.

(Plate x., figs. 7–13; plate xiii., figs. 1–9; plate xxiii., fig. 5.)

1870. *Polycheles stevensoni*, Brady and Robertson, Ann. and Mag. Nat. Hist., ser. iv., vol. vi., p. 25, pl. vii., figs. 1-7; and pl. x., figs. 4–14.

1870. *Argillæcia aurea*, Brady and Robertson, Ann. and Mag. Nat. Hist., ser. iv., vol. vi., p. 16, pl. viii., figs. 4, 5.

1872. *Darwinella stevensoni*, Brady and Robertson, ibid., ser. iv., vol., ix., p. 50.

1874. *Darwinella stevensoni*, Brady and Robertson, ibid., ser. iv., vol. xiii., p. 117, pl. v., figs. 8–10.

1874. *Darwinella stevensoni*, Brady, Crosskey, and Robertson, Post.-tert. Entom., p. 141, pl. ii., figs. 13–17.

Shell of the female, as seen from the side, oblong, depressed in front, height equal to more than one-third of the length; extremities obliquely rounded, anterior narrowed, posterior broad and obtuse: superior margin nearly straight, curving downwards in front of the middle; inferior slightly sinuated in the middle. Seen from above, ovate-acuminate, widest near the posterior extremity; greatest width about equal to the height; posterior margin indented in the middle at the junction of the two valves. End view nearly circular. Shell of the male somewhat more compressed; when seen from above, having the greatest width near the middle. The right valve much overlaps the left, especially in the middle of the ventral margin. Length, ·8 mm.

This is perhaps the most characteristic Entomostracan of the East Anglian Fen district, where it is widely spread, and often occurs in considerable abundance.

The following is a complete list of habitats, so far as known to us:—Whittlesea Dyke; Lake Lothing, and Breydon Water; Rivers Nene, Cam, Ouse, Deben; Wroxham, Barton, Horsey, Hickling, Somerton, Ormesby, and Oulton Broads, Loughs Inagh, Corrib, Agraffard, Arddery, and Nascrahoge in Connemara (G. S. B. and D. R.); Marbury Mere, Blackmere, and Osmere, Shropshire; White Loch and Borean Loch, Kirkcudbrightshire (G. S. B.); Broomhill Loch, Dumfriesshire, Mack Loch, near Oban; Canal at Cardiff (D. R.); Loch Fell, Wigtonshire, Lochs Aber and Ruter, Kirkcudbrightshire (A. M. N.).

Distribution.—River Scheldt, Holland (G. S. B.); Lac d'Ossegor, Cap Breton, S. W. France; Marquis de Folin (G. S. B.); Bedestresser See, N. Germany; S. A. Poppe (G. S. B.).

Fam. IV.—CYTHERIDÆ.

Genus I.—Metacypris, Brady and Robertson.

(Ann. and Mag. Nat. Hist., ser. iv., vol. vi. (1870), p. 19.)

[Type, *M. cordata*, Brady and Robertson.]

Shell moderately strong and thick. Seen from the side, the outline is subrhomboidal, rounded in front, and obscurely angular behind; the posterior portion of the hinge-margins produced angularly. Seen from above, heart-shaped in the female, broadly ovate in the male; ventral surface deeply inpressed along the central and posterior portions of the median line. Hingement formed on the *right* valve by a laminated angular projection anteriorly, posteriorly by a strong rectangularly-produced flange, from which projects a single sharply-cut tooth, the flange itself being continued round the posterior margin of the valve; on the *left* valve by a deep sulcus behind, and a shallower one in front. Except in front, and at the supero-posteal angle, the margins of the valves are incurved considerably, so that the actual contact-margins embrace a much smaller area than that of the entire shell. The right valve is larger than the left. Animal closely resembling *Cythere.*

Metacypris cordata, Brady and Robertson.

(Plate xiii., figs. 10–17; and Plate xiv., figs. 3–12.)

1870. *Metacypris cordata*, Brady and Robertson, Ann. and Mag. Nat. Hist., ser. iv., vol. vi., p 20, pl. vi., figs. 1–9.

1871. *Metacypris cordata*, idem, ibidem, vol. ix., p. 51, pl. ii., figs. 9, 10.

Shell of the female excessively tumid and depressed. Seen from the side, subovate or subrhomboidal; highest in the middle; height equal to more than half the length; anterior extremity well rounded, posterior obscurely angular; superior margin gently arched, produced at its posterior extremity into an angular process corresponding in position to the posterior hinge-joint; inferior margin

distinctly convex, curving upwards behind, in front rather deeply and abruptly sinuated at its junction with the anterior margin. Seen from above, the outline is heart-shaped, pointed in front, posterior extremity broadly rounded and indented at the junction of the two valves; greatest width situated behind the middle, much greater than the height, and equal to about five-sixths of the length; the lateral margins are boldly curved and somewhat sinuous in the anterior part of their course. End view subreniform, depressed; sides excessively convex; superior margin arched and slightly indented in the middle, inferior deeply sinuated in the middle, where, however, it is encroached on by the downwardly produced anterior margin.

The shell of the male differs in having an almost straight dorsal line, a very wide, obliquely truncated postero-dorsal angle, and in the ventral margin being rounded off behind with a bold curve. Seen from above, the outline, instead of being cordate, is ovate, and widest in the middle, the posterior extremity being narrowed and rounded off. Surface closely set with small, rounded impressions, which on the ventral surface are arranged in longitudinal rows, and tend to run into furrows; ventral surface deeply sulcate along the greater portion of the median line. Colour green, with irregular blotches of darker green, or black. Length ·5 mm.

Antennules slender, six-jointed; the third, fourth, and sixth joints nearly equal in length; fifth slightly longer; last joint bearing four slender setæ, two of which are moderately long; fourth and fifth joints also bearing two or three slender apical setæ; antennæ, jaw, and feet as in *Cythere;* the mandible-palp, however, short, indistinctly jointed, and bearing an appendage composed of three segments, the two larger of which bear each two setæ, the smaller one seta; abdomen ending in two short curved setæ.

This remarkable species was first found in several gatherings from the East Anglian Fen district, viz. Rivers Nene and Cam, Wroxham and Barton Broads, and Breydon Water (G. S. B. and D. R.). All the specimens from these localities, however, were only dead shells. More recently we have been fortunate enough to find perfect animals in Coolbareen Lough, Co. Mayo, and Lough Aubwee, near Galway, from which the anatomical characters have been gathered. All these specimens were females; but in some later gatherings from Ellesmere Canal, Osmere, and Colmere, Shropshire (G. S. B.), we have found a few males.

Disrtibution.—In dredged sand from the River Scheldt, Holland (G. S. B.).

Genus II.—Cythere, Müller.

[Type, *Cythere lutea*, Müller.]

1. *Cythere lutea*, Müller.

Synonyms: *Cythere reniformis*, Baird; *C. setosa*, Brady.

1868. *Cythere lutea*, Brady, Mon. rec. Brit. Ostrac., p. 395, pl. xxvii., figs. 47–58; pl. xxxix., fig. 2.
1868. *Cythere viridis*, Brady, Mon. rec. Brit. Ostrac., p. 397, pl. xxviii., figs. 40, 41, and 50–59; pl. xxxviii., fig. 8 (but not *Cythere viridis*, Müller), (*junior*).
1874. *Cythere lutea*, Brady, Crosskey, and Robertson, Mon. Post-tert. Entom., Scotland, p. 148, pl. iii., figs. 1–6.
1874. *Cythere viridis*, Brady, Crosskey, and Robertson, Mon. Post-tert. Entom., Scotland, p. 147, pl. iii., figs. 26–28 (*junior*).
1888. *Cythere lutea*, Dahl, Die Cytheriden der Westlich. Ostsee, p. 9, pl. i., figs. 1–12, 27–29.

Cythere lutea occurs commonly all round the coasts of the British Islands in the littoral and laminarian zones, extending to considerable distances up river estuaries, such as those of the Stour and Deben, in Suffolk. When living amongst algæ, it is usually deeply coloured in the central portion of the shell with a yellowish or reddish-brown incrustation; but specimens dredged from greater depths are of a uniform dirty-grey tint.

Distribution.—Norway, frequent (G. O. Sars); Dröbak; Lervig, in Hardanger Fiord; Bukken, Kors Fiord, Norway. Holstenbourg and Godhavn Harbours, Greenland; Davis Strait, lat. 76° 17′ N., long. 62° 21′ W., just below low-water mark; "Valorous" Exped. (A. M. N.); Mediterranean; Iceland; Hammerfest Harbour; Gulf of St. Lawrence (G. S. B.).

Fossil.—Scotland, Belfast, Iceland, Canada, Norway.

It will thus be seen that this very common British Cythere has a most extensive range both at the present and in the post-tertiary epoch.

2. *Cythere pellucida*, Baird.

(Plate XIV., figs. 13–15.)

1850. *Cythere pellucida*, Baird, British Entomostraca, p. 173, pl. xxi., fig. 7 (*e typis*).
1865. *Cythere castanea*, G. O. Sars, Oversigt af Norges marine Ostracoder, p. 32.
1868. *Cythere castanea*, Brady, Mon. rec. Brit. Ostrac., p. 398, pl. xxviii., fig. 27; and pl. xxxviii., fig. 6.
1869. *Cythere castanea*, Brady and Robertson, Ann. and Mag. Nat. Hist., ser. IV., vol. iii., pl. xix., figs. 15–18.
1874. *Cythere castanea*, Brady, Crosskey, and Robertson, Mon. Post-tert. Entom., p. 143, pl. xiii., figs. 8–11; and pl. iii., fig. 25.

For habitats of this species, see under *Cythere castanea*, in Brady's monograph. The type specimens of Dr. Baird's *Cythere pellucida* from Boston are in Dr. Norman's collection, and they are not the species which has been regarded by authors as *C. pellucida*, but are the form named by Sars, *C. castanea*. The ordinary specimens of the latter form are smaller than the former (*i. e.* the *Cythere confusa* of this memoir); but Dr. Baird's Boston specimens are smaller still, though decidedly the same as *C. castanea*, with which they agree in all characters. The transverse furrow, which is neither referred to nor figured by Baird, is as distinct in these specimens as usual.

This is essentially a brackish-water species, and is found all round the coasts of Great Britain and Ireland in salt marshes and estuaries, and in rivers as far as, or even further than, the tidal influence extends. We have found it in places as far inland as Whittlesea, and in several of the Norfolk and Suffolk Broads (G. S. B. and D. R.). It occurs also not uncommonly in dredgings from shallow water up to 4 or 5 fath., and less commonly up to 30 fath.

Distribution.—Christiania, Norway (G. O. Sars); Hollingspollen, Dröbak; and Bergen, Norway; Fosse de Cap Breton, Bay of Biscay, in 180–200 fath., but probably washed into that deep trough from shallow water, as it is usually an estuarine and shallow-water species (A. M. N.); Rivers Scheldt and Maas, Holland (G. S. B.); Naples (A. M. N.).

Fossil.—Scotland, Cardiff (New Dock Basin).

3. *Cythere confusa*, nom. nov.

(Plate XIV., figs. 16–18.)

1865. *Cythere pellucida*, G. O. Sars, Oversigt af Norges marine Ostracoder, p. 31 (but not of Baird).
1868. *Cythere pellucida*, Brady, Mon. rec. Brit. Ostrac., p. 397, pl. xxviii., figs. 22–26, 28.
1869. *Cythere pellucida*, Brady and Robertson, Ann. and Mag. Nat. Hist., ser. IV., vol. iii., pl. xix., figs. 10–12.
1874. *Cythere pellucida*, Brady, Crosskey, and Robertson, Mon. Post-tert. Entom., p. 142, pl. iii., figs. 20–24.
1884. *Cythere pellucida*, Carus, Prod. Faunæ Medit., p. 294.

This is more strictly a marine species than *C. pellucida*, and is not so universally found in tidal or brackish waters, though we have records of its occurrence in many such situations on the Northumberland coast, as well as in the Rivers Humber, Ouse (Yorkshire and Norfolk), and Thames; at Whittlesea and in Breydon Water, Norfolk. In deep water all round our coasts it is found more abundantly than *C. pellucida.*

Distribution.—Christiania to Finmark (G. O. Sars); Haakelsand, in Kors Fiord; Lervig Bay; Dröbak; all in Norway (A. M. N.); Iceland; Holland, River Scheldt (G. S. B.); Fosse de Cap Breton, Bay of Biscay (A. M. N.); Messina (Seguenza), Mediterranean, St. Malo, Syra, Smyrna (G. S. B.); Gulf of St. Lawrence (G. S. B.); Naples (A. M. N.).

Fossil.—Scotland; Ireland, at Belfast and Portrush; Norway; Sicily.

4. *Cythere porcellanea*, Brady.

(Plate XIV., figs. 22, 24.)

1869. *Cythere porcellanea*, Brady, Ann. and Mag. Nat. Hist., ser. IV., vol. iii., p. 47, pl. vii., figs. 1–4 (*junior*).
1869. *Cythere porcellanea*, Brady and Robertson, ibid., p. 367, pl. xix., figs. 1–4.
1869. *Cythere propinqua*, G. O. Sars, Undersögelser over Christianiafjordens Dybvandsfauna, p. 57, and note, p. 58.
1874. *Cythere porcellanea*, Brady, Crosskey, and Robertson, Mon. Post-tert. Entom., p. 144, pl. xiii., figs. 1, 2.

Shell of female, seen from the side, flexuous, reniform, highest in the middle, greatest height equal to rather more than half the length; anterior extremity evenly, posterior obliquely, rounded; superior margin evenly arched, inferior deeply sinuated in the middle; postero-superior angle well marked. Seen from above, ovate, widest in the middle, sharply pointed in front, rather more obtusely

behind; width somewhat less than the height. Surface smooth and polished, marked (usually behind the middle) with a few scattered, indistinct puncta. Colour, whitish. Shell of the male rather more slender, and less flexuous. Length, ·5 mm.

In brackish estuaries and in the sea, but apparently seldom reaching beyond the littoral and laminarian zones. The distribution is, in fact, almost exactly that of *C. pellucida*, ranging from such fresh-water habitats as Whittlesea, on the one hand, to depths of 30–40 fathoms on the other.

Distribution.—Christiania Fiord (G. O. Sars); Bergen, Lervig, and Dröbak, Norway (A. M. N.); Iceland; Rivers Scheldt and Maas, Holland (G. S. B.).

Fossil.—Scotland; Cardiff, South Wales.

Although the characters above given are undoubtedly sufficient to separate well-marked examples very decidedly from any of the most nearly related species, *C. confusa*, *C. pellucida*, and *C. macallana*, it must yet be admitted that there occur many intermediate conditions, which it is by no means easy to assign without misgiving to any one of these species. But a similar observation holds good in numberless other cases, and is, in fact, only one of many points of evidence in favour of community of descent, and of organic plasticity sufficient to adapt forms to constantly varying conditions of existence. The characters on which we chiefly rely to distinguish *C. porcellanea* from its near allies are—firstly, the nearly equal tapering of both extremities when seen from above, that is dorsally; secondly, the more arched and flexuous outline as viewed laterally; thirdly, the smooth porcellaneous shell-surface, with little trace of punctation; and, lastly, that in the females there is no transverse furrowing of the shell, in this respect resembling *C. macallana*.

5. *Cythere macallana*, Brady and Robertson.

(Plate XIV., figs. 19–21.)

1869. *Cythere macallana*, Brady and Robertson, Ann. and Mag. Nat. Hist., ser. IV., vol. iii., p. 368, pl. xix., figs. 5–9.

1874. *Cythere macallana*, Brady, Crosskey, and Robertson, Mon. Post-tert. Entom., p. 144, pl. xiii., figs. 1, 2.

Shell of the female, as seen from the side, subreniform, greatest height in front of the middle, and equal to half the length; anterior extremity evenly, posterior obliquely, rounded; dorsal margin rather boldly arched, ventral sinuated in the middle. Seen from above, ovate, widest in the middle, rounded behind, subacuminate in front; width less than the height. Shell of the male longer and narrower, as seen laterally more tapering towards the posterior extremity;

dorsal margin almost straight. Seen from above, the sides are sub-parallel, and the posterior extremity obtuse. Length, ·4 mm.

This species has been dredged in Dublin, Westport, Birturbuy and Clifden Bays, Ireland, and off the Scilly Islands; and found in sands from the Yorkshire River Ouse, the Humber, and Fowey Harbour (G. S. B. and D. R.). Dredged in 5 fathoms off Fairlie, Firth of Clyde, and in Clew Bay, Mayo (A. M. N.); Belfast Lough and Irish Channel (Malcomson).

Distribution.—Naples (A. M. N.).

Fossil.—Kilchattan and Cumbrae, Scotland.

6. *Cythere tenera*, Brady.

1868. *Cythere tenera*, Brady, Mon. rec. Brit. Ostrac., p. 399, pl. xxviii., figs. 29–32.
1874. *Cythere tenera*, Brady, Crosskey, and Robertson, Mon. Post-tert. Entom., p. 145, pl. xiii., figs. 6, 7.
1880. *Cythere tenera*, Brady, Report "Challenger," Ostracoda, p. 63, pl. xii., fig. 3 *a–f*.
1885. *Cythere tenera*, Carus, Prod. Faunæ Medit., p. 295.

This species is easily distinguished from the four preceding not only by its contour, but by its characteristic surface-markings, and the absence of transverse furrowing.

Except that it is less common in fresh and brackish water, its distribution follows exactly the lines of *C. pellucida* and *C. porcellanea.* The most characteristic specimens occur in purely marine situations, but numerically they are not so common as the two above-mentioned species. From fresh-water, our only recorded locality is Whittlesea Dyke (G. S. B. and D. R.). Between tide-marks it seems to be of rare occurrence, our only records of such habitats being Whitley and Cullercoats, Northumberland (G. S. B.).

Distribution.—Oster Fiord, near Bergen, 100 fath.; Hardanger Fiord, off Lervig and Dröbak, Norway; Fosse de Cap Breton, Bay of Biscay, 30–200 fath. (A. M. N.); Vigo Bay, "Challenger" Expedition (G. S. B.); Messina (Seguenza); Besika Bay; Hellespont; Rivers Scheldt and Maas, Holland (G. S. B.).

Fossil.—Scotland, Cardiff.

7. *Cythere mamillata*, Brady.

(Plate xx., figs. 32, 33.)

1866. *Cythere mamillata*, Brady (New or imperfectly known species of Ostracoda), Trans. Zool. Soc., vol. v., p. 373, pl. lix., figs. 6 *a–c*.

Shell oblong, subreniform, deepest in front, twice as long as high; anterior margin well rounded, produced downwards below the level of the ventral margin; posterior extremity narrow, bent in the middle at an obtuse angle; dorsal margin arched; ventral straight. Seen from above, oval. Surface of the valves minutely punctate, and raised into several irregularly placed, rounded elevations, or mamillæ. Length, ·32 mm.

Habitat.—Atlantic Ocean, 110 fathoms (G. S. B.).

8. *Cythere* (?) *semipunctata*, Brady.

1868. *Cythere* (?) *semipunctata*, Brady, Mon. rec. Brit. Ostrac., p. 411, pl. xxix., figs. 33–38.
1874. *Cythere* (?) *semipunctata*, Brady, Crosskey, and Robertson, Mon. Post-tert Entom., p. 172; pl. xvi., fig. 11–12.

This is a species of which the animal is still unknown, and the shell presenting some unusual characters, its position in this genus remains doubtful.

Cythere semipunctata is widely distributed, but always scarce where found.

Additional localities.—Budle Bay and Seaton Sluice, Northumberland; off coasts of Durham and North Yorkshire; River Ouse, Norfolk; off the Eddystone Lighthouse; Ilfracombe; Scilly Isles; Westport Bay and Mulroy Lough, Ireland (G. S. B. and D. R.); off Tarbert, Loch Fyne; between the Cumbraes, Firth of Clyde, in 25 fath. (A. M. N.); Irish Channel and Belfast Lough (Malcomson).

Distribution.—Lervig Bay, Norway; Fosse de Cap Breton, Bay of Biscay, 30–200 fath. (A. M. N.).

9. *Cythere badia*, Norman.

(Plate xv., figs. 3, 4.)

1868. *Cythere badia*, Brady, Mon. rec. Brit. Ostrac., p. 399, pl. xxix., figs. 29–32.

The figures and descriptions of this species given in the "Monograph" are correct, and apply to the species originally described by Dr. Norman; but the

synonym *cicatricosa* is referable to a closely-allied form, *C. crispata*, which was supposed to be identical with *C. badia*. Several of the habitats there assigned to *C. badia* belong properly to *C. crispata*. The following list shows completely the present state of our knowledge as to the distribution of *C. badia*:—

Fowey Harbour and Dungeness Bay (G. S. B.); Kames Bay, in the Isle of Cumbrae, and Westport Bay, Ireland; Scilly Isles (G. S. B. and D. R.); Rock pools, at Mounts Bay, Cornwall; Herm; Guernsey; Arran and Lough Carron, N. B.; Roundstone Bay, Ireland (A. M. N.); Belfast Lough and Irish Sea (Malcomson).

Distribution.—Mediterranean, Syra, Smyrna, Constantinople (G. S. B.).

10. *Cythere crispata*, Brady.

(Plate xv., figs. 1, 2.)

1865. *Cythere cicatricosa*, G O. Sars, Oversigt af Norges marine Ostracoder, p. 33 (*not* Reuss).
1868. *Cythere badia*, Brady, Les Fonds de la Mer., vol. i., p. 89.
1868. *Cythere crispata*, Brady, Ann. and Mag. Nat. Hist., ser IV., vol. ii., p. 221, pl. xiv., figs. 14, 15.
1869. *Cythere cicatricosa*, Brady and Robertson, Ann. and Mag. Nat. Hist., ser. IV., vol. iii., p. 369, pl. xix., figs. 13, 14.
1869. *Cythere badia* (in part), Brady, Mon. rec. Brit. Ostrac., p. 399 (not figures).
1874. *Cythere crispata*, Brady, Crosskey, and Robertson, Mon. Post-tert. Entom., p. 146, pl. xii., figs. 52, 53; and pl. xiii., figs. 12, 13.
1880. *Cythere crispata*, Report "Challenger," Ostracoda, p. 72, pl. xiv., figs. 8 *a–d*.
1883. *Cythere crispata*, Seguenza, Il Quaternario di Rizzolo, II., Gli Ostracodi, p. 30.
1885. *Cythere crispata*, Carus, Prod. Faunæ Medit., p. 295.

Carapace of the *female*, as seen from the side, subreniform, higher in front than behind, greatest height in front of the middle, and equal to more than half the length; anterior extremity rounded, and often slightly crenulated below the middle; posterior truncated and slightly rounded at the angles; superior margin gently arched, sloping from before backwards, its posterior angle somewhat produced; inferior margin slightly sinuated in the middle. Seen from above, the outline is compressed, almost clavate, tapering, and narrowly rounded in front, truncated behind; lateral margins deeply emarginated near the posterior extremity; width considerably less than half the length. Surface of the shell marked with irregularly sinuous depressions, and often with well-marked intervening ridges. Colour, yellowish-brown; the raised ornament often of a deeper tint of blue or black. Shell of the male longer, narrower, and more flexuous in outline. Length, ·42 mm.

As already observed, this species was, in the "Monograph" confounded with *C. badia*, which, however, has only an irregular surface ornament, without

the conspicuous sinuations and rugæ which mark *C. crispata;* the dorsal aspect of the former is regularly ovate, while that of the present species is distinctly truncate behind, and has well-marked lateral notches.

The specific name *cicatricosa*, applied by G. O. Sars to this species, having been pre-occupied by Reuss and Bosquet for a form closely allied to, if not identical with, Baird's *C. convexa*, we adopt the name *crispata* already proposed by one of us for a Mediterranean form which we believe to be only a more strongly marked variety of this species, differing chiefly in size, and in the prominence of the sculptured shell-markings. This southern form approaches very closely *C. canaliculata* of Reuss, which, however, according to the figures given by that author, is even more sharply sculptured. A specimen, referred to *C. canaliculata*, was figured in the "Transactions of the Zoological Society" (vol. v., 1866, p. 373, pl. lix., figs. 4 *a–d*), and others more completely in the Report on the Ostracoda, of the "Challenger" Expedition (p. 73, pl. xiv., figs. 7*a–d*). The British *C. crispata*, smaller and less pronounced in character than those from more southern seas, may fairly be looked upon as depauperized examples of a species finding more favourable conditions in warmer latitudes. The species ranges from Norway, Britain, and the Mediterranean, to Australia and Hong-Kong.

C. crispata appears to occur all round the British coasts from low-water mark downwards.

Distribution.—Christiania Fiord, Norway (G. O. Sars); Mediterranean, Tenedos, Besika Bay, and Hellespont (G. S. B.); Messina (Seguenza); Port Jackson, Australia; Booby Island; Hong-Kong Harbour, "Challenger" (G. S. B.).

Fossil.—Scotland, Ireland, Norway, Sicily.

This species is usually an inhabitant of the Laminarian Zone; while *C. badia* affects tide-marks.

11. *Cythere cribrosa*, Brady, Crosskey, and Robertson.

(Plate XVI., figs. 17, 18.)

1874. *Cythere cribrosa*, Brady, Crosskey, and Robertson, Mon. Post-tert. Entom., p. 146, pl. x., figs. 5–7.

1878. (?) *Cythere cribrosa*, Brady, Ostracoda, Antwerp Crag, Trans. Zool. Soc., p. 384, pl. lxiv., figs. 4 *a–b*.

1886. *Cythere cribrosa*, Malcomson, Recent Ostracoda of Belfast Lough (Proc. Belfast Naturalists' Field Club), p. 260.

Shell compressed, oblong; seen laterally, rather higher in front than behind; greatest height equal to half the length; anterior extremity evenly, posterior

obliquely rounded, and obsoletely angular about the middle; superior margin gently arched, highest in front of the middle, and terminating behind in an obtuse angle; inferior almost straight. Seen from above, compressed, ovate; anterior extremity sub-acuminate, posterior narrowly rounded, width less than the height. End view sub-circular. Surface of the valves covered with rather closely reticulated furrows which assume a concentric arrangement towards the margins. Length, ·55 mm.

A very pretty and distinct species, its nearest relative being perhaps *C. robertsoni*, from which it differs chiefly in the character of its surface-marking, in its somewhat greater size and less angular form.

As we do not possess a recent specimen we are obliged to describe and figure the species from fossil examples.

The late Dr. Malcomson found a single specimen of this form at Rockport, Co. Down, in 4 fathoms.

Fossil.—Bridlington, Yorkshire; (?) Belgium (Antwerp).

12. *Cythere teres*, Brady.

(Plate xiv., figs. 36, 37.)

1869. *Cythere teres*, Brady, Les Fonds de la Mer., vol. i., p. 147, pl. xiv., figs. 17, 18.

Shell, seen from the side, elongated, subreniform, height nearly the same throughout, and scarcely equal to half the length; anterior extremity evenly, posterior obliquely rounded; dorsal margin almost straight, ventral very slightly sinuated in the middle. Seen from above, the outline is elongated, ovate, narrowed, and obtusely pointed in front; broad, and subtruncate behind, where there is a median triangular prominence. The surface of the valves is smooth and glistening, of a pale straw-colour, mottled with pellucid patches. Length, ·5 mm.

Dredged in Dartmouth Harbour, 3–5 fath. (A. M. N.); Bay of Biscay (G. S. B.).

13. *Cythere sulcifera*, Brady.

(Plate xix., figs. 22, 23.)

1886. *Cythere sulcifera*, Brady, Les Fonds de la Mer, vol. iv., p. 197, pl. xv., figs. 3, 4.

Shell, viewed laterally, ovate; greatest height central, and equal to half the length; anterior extremity very wide, evenly and regularly rounded, the margin above sweeping evenly and regularly, without the slightest sign of angularity until

it reaches the highest portion of the valves, which is in their centre; posterior margin very much narrower than the anterior, subtruncate, with an angularity at the junction with the dorsal slope; in some specimens (? males) the angularity is greater, and takes the form of a pouting lip; the lower portion edged with a row of small tubercular teeth; dorsal margin well arched, forming a continuous sweep, the anterior portion of the arch declines much less suddenly than the posterior, as in the latter case it has to meet the narrower termination; ventral margin straight. Seen from above, much compressed, narrowly elliptic; greatest tumidity posterior, attenuated evenly at the narrow extremities. Surface of valves perfectly smooth on the front half, hinder portion sculptured with longitudinal waved riblets and furrows, which sometimes, especially towards the dorsal margins, are crossed by more slender riblets; but the marked character consists in the former. Length, ·9 mm.

Habitat.—"Porcupine" Exped., 1869. Stat. 19, east of Donegal Bay, in lat. 54° 53′ N., long. 10° 56′ W., 1360 fath.; and Stat. 42, lat. 49° 12′ N., long. 12° 52′ W., 862 fath. (A. M. N.).

14. *Cythere corpulenta*, n. sp.

(Plate XVI., figs. 11, 12.)

Shell ovate, very compressed in front, much swollen behind, especially towards the ventral margin, over which it swells in a corpulent manner; greatest height nearly central, more than equal to half the length; anterior extremity broad, remarkably, broadly, and evenly rounded, the anterior third of the shell having a semicircular outline; posterior extremity much narrower, obtusely rounded or subtruncate, with a rounded angularity at its junction with the dorsal margin; dorsal margin arched, the anterior slope very slight, the posterior greater, but regular; ventral margin straight, but overhung by the convex outline of the obesity of the valves. Seen from above, somewhat narrowly heart-shaped; greatest width near the hinder extremity, where the sides rapidly but arcuately converge, while the extremity itself is slightly exserted; towards the front the attenuation is gradual and even, the extremity narrow. Valves very flat in front, and also at the extreme posterior portion; in the middle and behind the middle very obese; greatest tumidity close to, and overhanging the ventral margin; surface of valves finely punctate, and sculptured with a few longitudinal thread-like riblets. Length, ·60 mm.

Cythere corpulenta is, perhaps, more nearly allied to *C. sulcifera* than to any other species described in this Memoir, and has much the aspect of a *Loxoconcha*.

Habitat.—This species has only been found in Oster Fiord, a narrow and very deep inlet, about 15 (?) miles north of Bergen, Norway. It was there met with in four different dredgings, in depths ranging from 100 to 375 fathoms, but in each case only a single example occurred (A. M. N.).

15. *Cythere lamellifera*, n. sp.

Shell, seen from the side, cuneiform; greatest height anterior, somewhat less than half the length; anterior extremity remarkable on account of its broad and even roundness; the point of greatest protrusion is central, and the arcuation both above and below this is bold, even, and regular; the dorsal margin at about two-fifths of its length from the anterior extremity slopes gradually backwards until near the hinder end, where a sudden declivity forms an obliquely truncate posterior extremity, the point of greatest protrusion of which is inferior; ventral margin with a small but deep sinus near the posterior extremity. The greatest tumidity is over this sinus, behind which there is a sudden depression of the valve, while forwards the compression is gradual, until the anterior portion of the valve is at once much outspread and compressed. Round the anterior margin runs a smooth fillet, and at a short distance within this a second narrow fillet; the space between is grooved, the groove being traversed by a few faint, transverse, thread-like lines; general surface of valves sculptured with several longitudinal, little-elevated, lamelliform, slender, smooth, ribs; posterior margin set round with obtuse tubercles; similar tubercles, but of much smaller size, are also to be seen round the anterior edge. Length, about ·4 mm.

A single valve dredged by H. M. S. "Valorous," in 1875. Stat. 16, lat. 55° 10′ N., long. 25° 55 W., in 1785 fath. (A. M. N.).

It is not satisfactory to describe a species from a single valve; but this seems very distinct from all known forms, and from the extreme depth at which it was found we cannot expect that many examples should be discovered.

We are unable to give an illustration, as the valve was unfortunately broken in the process of examination.

In form this species approaches nearest perhaps to *C. dorsoserrata*, Brady, described in the "Challenger" Report, from specimens taken near Tristan d'Acunha.

16. *Cythere amissa*, n. sp.

Shell subovate or nearly semicircular, the semicircle broken by a projected process at the posterior extremity; greatest height nearly central, and more than half the length; anterior margin having its greatest prominence near the junction with the ventral, thence sweeping with a long regular curve to the highest point of the shell, which is nearly central; posterior margin subtruncate above, below protruded into a rostrate process (such as is common in the genus *Cytherura*); dorsal margin arcuate throughout, without any angularity before or behind; hinder declination more sudden than that in front; ventral margin slightly convex. Surface of valves sculptured all over with deep pits, which are mostly quadrangular, separated from each other by sharply-cut boundary walls; the edges of the valves are on all sides a little turned up, and form a narrow but distinct bordering-line. Seen from above, diamond-shaped, but with the terminal angles blunt, and the lateral rounded off; ends equal. Length, about ·75 mm.

Habitat.—Fosse de Cap Breton, Bay of Biscay, 30–60 fath.; a single specimen (A. M. N.).

Unfortunately, just as the description was written, and while measuring the shell, it was let fall on the carpet, and all attempts to find it were in vain. We are thus unable to give a figure. *C. amissa* is very distinct from all described Cytheres known to us. The nearest thing to it is *Cythere convoluta*, Brady (Ann. Nat. Hist., ser. iv., vol. ii., p. 182, pl. xxi., figs. 3, 4), a species from the Mauritius. From that species *C. amissa* differs in not having the retusion at the infero-posteal angle; not any angularity at the junction of the dorsal and hinder margins, the dorsal margin sweeping right down to the rostrate process. Seen from above, the ends are much narrower, and the sides not sinuated; the surface of the valves have not the flange beyond the encircling riblet, while the sculptured cells are smaller and more numerous.

17. *Cythere gibbosa*, Brady and Robertson.

(Plate xiv., figs. 30, 31).

1869. *Cythere gibbosa*, Brady and Robertson, Ann. and Mag. Nat. Hist., Ser. iv., vol. iii., p. 368, pl. xxi., figs. 1–3.

1874. *Cythere gibbosa*, Brady, Crosskey, and Robertson, Mon. Post-tert. Entom., p. 150, pl. xvi., figs. 16–18.

Shell of female tumid; seen from the side oblong, subtriangular or subtrapezoidal, highest in front of the middle; height equal to at least half the

length; anterior extremity obliquely, posterior evenly rounded, the latter the narrower; dorsal margin prominent in front of the middle, thence sloping steeply to the front, but more gently and almost in a right line backwards; ventral almost straight. Seen from above the outline is ovate; widest near the middle, the width being considerably less than the height; extremities acuminate. End view broadly ovate. Shell of the male narrower and longer. Valves rather thin, fragile, smooth and polished, bearing a few scattered hairs, which are papillose at the base; ventral surface longitudinally depressed in the middle. Length, ·4 mm.

Found in a large tidal pond at Westport Quay, Co. Mayo, amongst *Zostera;* Roundstone; Mulroy Lough; Canal at Belfast; Kames Bay, Isle of Cumbrae; Isle of Skye; Greenock; Loch Gilp; and Montrose. Budle Bay, and several estuarine situations on the Northumberland Coast and Thames Estuary (G. S. B. and D. R.). Mouth of the Tweed; Seaton-Carew Marshes, Co. Durham; and Newport, Co. Mayo (A. M. N.). Five miles S. S. E. of Maidens Lighthouse, Irish Channel, in 60 fathoms; Rockport, Co. Down (Malcomson).

Distribution.—Cape Frazer, 50–80 fath., Capt. Feilden's dredgings (G. S. B.).

This species is for the most part a denizen of brackish waters. The foregoing list of localities, with the exception of Kames Bay, the Irish Channel, and Cape Frazer, presents us with such habitats; for Mulroy Lough and Roundstone Bay, though inlets of the sea, are both of them subject to a large influx of fresh water, and at low tide must be only feebly saline. Budle Bay, on the other hand, is a large, muddy expanse, covered by the sea at high water, while at low water a small stream finds its way through it to the sea.

18. *Cythere rubida*, Brady.

(Plate xv., figs. 22, 23.)

1866. *Cythere rubida*, Brady, Mon. rec. Brit. Ostrac., p. 400, pl. xxxii., figs. 71–74.
1869. *Cythere drammensis*, G. O. Sars, Undersögelser over Christianiafjordens Dybvandsfauna, p. 56.

The only locality given in the Monograph was Clachland Point, Arran, N. B. (A. M. N.). It has since been found in Kames Bay, Isle of Cumbrae (D. R.), and Rockport, Co. Down (Malcomson). It is a very rare form, though stated by Prof. G. O. Sars to be of frequent occurrence in Drammen Bay, on the Christiania Fiord, where he took it in company with lacustrine species.

19. *Cythere oblonga*, Brady.

1866. *Cythere oblonga*, Brady, Mon. rec. Brit. Ostrac., p. 400, pl. xxxi., figs. 14–17.
1885. *Cythere oblonga*, Carus, Prod. Faunæ Mediterraneæ, p. 297.

Originally described from a sponge-sand specimen; again in the "Monograph" from specimens found in shell-sand at the Mumbles; more recently we have dredged it among the Scilly Islands (G. S. B. and D. R.); Salcombe, Devon, and Plymouth (A. M. N.).

Distribution.—Dröbak, Norway, in 30–120 fath.; Fosse de Cap Breton, Bay of Biscay, 25–60 fath. (A. M. N.); St. Malo; Messina, and other parts of the Mediterranean (G. S. B.).

Fossil.—Sicily (Seguenza).

20. *Cythere albomaculata*, Baird.

Synonym: *C. alba*, Baird, *junior*.

1865. *Cythere albomaculata*, Brady, Mon. rec. Brit. Ostrac., p. 402, pl. xxviii., figs. 33–39; pl. xxxix., figs. 3 *a-k*.
1874. *Cythere albomaculata*, Brady, Crosskey, and Robertson, Mon. Post-tert. Entom., Scotland, p. 149, pl. ix., figs. 1–4.
1884. *Cythere albomaculata*, Seguenza, Il Quaternario di Rizzolo II. Gli Ostracodi, p. 26.
1885. *Cythere albomaculata*, Carus, Prod. Faunæ Mediterraneæ, p. 296.

C. albomaculata is a sub-boreal type, rare on the Norwegian coast; absent, so far as we know, from the Arctic Ocean, but found abundantly all round the British coasts in the littoral and laminarian zones; and running to a considerable distance up tidal rivers. It seems, however, to be absent from the Broads of Norfolk and Suffolk (G. S. B. and D. R.), though G. S. B. has found it in a freshwater lake at Bolam, Northumberland. Specimens taken between tide-marks and amongst algæ are generally beautifully maculated, but those from sandy and muddy bottoms are destitute of colour.

Distribution.—Lervig, Stordoen, Norway (A. M. N.). Iceland, Eastern Mediterranean and Constantinople; Cape Verd; Bay of Biscay and Vigo; Fosse de Cap Breton, 25 faths. (G. S. B.).

Fossil.—Scotland; Portrush, Ireland; Sicily.

21. *Cythere leioderma*, Norman.

(Plate xv., figs. 12, 13.)

1869. *Cythere leioderma*, Norman, Brit. Assoc. Report, 1868, p. 291.
1870. *Cythere leioderma*, Brady, Ann. Mag. Nat. Hist., ser. iv., vol. vi., p. 451, pl. xix., figs. 11–13.
1874. *Cythere leioderma*, Brady, Crosskey, and Robertson, Post-tert. Entom., p. 149, pl. ix., figs. 5, 6.
1883. *Cythere leioderma*, Seguenza, Il Quaternario di Rizzolo II. Gli Ostracodi, p. 27.

Shell, seen from the side, oblong, subquadrangular, rather higher in front than behind; greatest height equal to a little more than half the length; anterior extremity somewhat obliquely rounded, posterior truncated and slightly produced below the middle; dorsal margin highest in front, where it is obscurely angulated, thence sloping gently, and almost in a straight line backwards; ventral margin very slightly sinuated in the middle. Seen from above, the outline is sub-elliptical, nearly twice as long as broad, slightly widest behind the middle; extremities very broadly rounded and nearly equal. Shell surface smooth, marked with a few scattered, short, and rigid setæ, which in some lights look deceptively like small circular papillæ. Hinge margins depressed, processes very strongly developed but not crenulated. Colour, yellowish or milky-white. Length, 1 mm.

Habitat.—Unst Haaf, Shetland (A. M. N.).

Distribution.—Solems Fiord, Norway, 50–60 fathoms, a single specimen (A. M. N.). Abundant, in a living state, in the Gulf of St. Lawrence; Iceland; Cape Frazer, 80 faths.; and Dobbs Bay, 46 faths., 79° 35′ N., Captain Feilden's dredgings (G. S. B.).

Fossil.—A single valve has been recorded from the Post-tertiary Strata, at Bridlington, Yorkshire; and Prof. Seguenza has met with a single valve at Rizzolo, in Sicily.

22. *Cythere robertsoni*, Brady.

(Plate xiv., figs. 32, 33.)

1868. *Cythere robertsoni*, Brady, Ann. and Mag. Nat. Hist., ser. iv., vol. ii., p. 33, pl. iv., figs. 5, 8–10.
1874. *Cythere robertsoni*, Brady, Crosskey, and Robertson, Post.-tert. Entom., p. 221.

Shell of the *female* compressed. Seen from the sides, subcuneiform, much higher in front than behind, greatest height situated in front and equal to rather more than half the length; anterior extremity broad and well-rounded, posterior

narrow and obliquely rounded; superior margin nearly straight, sloping steeply from the front backwards; inferior sinuated in the middle, curved upwards behind. Seen from above, compressed, oblong, with nearly parallel sides; anterior extremity sharply pointed, posterior suddenly tapered and obtuse, width much less than the height. End view ovate, widest in the middle. Shell of the *male* much narrower. Surface covered with closely-set, angular depressions. Colour, yellowish. Length, ·48 mm.

A small, but very distinct and pretty species, described first from specimens dredged by Mr. D. Robertson, at Dröbak, Christiania Fiord, in a depth of 30–35 fathoms.

We have no record of this pretty and well-marked species from any part of the Scottish coast north of Loch Fyne. In Ireland we have found it in Dublin and Westport Bays, and Dr. Malcomson dredged it in Belfast Lough and the Irish Channel. Round the English coast it occurs generally, ranging from tide-marks into all depths of water, always, however, rather sparingly.

Distribution.—Dröbak, Norway (D. R.). Again in the last locality in 10–120 fathoms; and in Stoksund, which is near the mouth of the Hardanger Fiord, Norway, in 126 fathoms (A. M. N.).

Fossil.—Scotland, Loch Gilp; Norway.

23. *Cythere convexa*, Baird.

Synonym.—*C. punctata*, R. Jones.

1868. *Cythere convexa*, Brady, Mon. rec. Brit. Ostrac., p. 401, pl. xxix., figs. 19–27; pl. xxxix., fig. 4.

1874. *Cythere convexa*, Brady, Crosskey, and Robertson, Mon. Post-tert. Entom., p. 150, pl. iii., figs. 14–17.

1884. *Cythere convexa*, Seguenza, Il Quaternario di Rizzolo II. Gli Ostracoda, p. 20.

1885. *Cythere convexa*, Carus, Prod. Faunæ Medit., p. 295.

Cypridina cicatricosa of Reuss was given in the Monograph with a (?) as a synonym of this species. It has been regarded by the authors of the "Monograph of Post-tertiary Entomostraca" as a distinct species, of which *Cythere cicatricosa*, Bosquet, and *Cythere arborescens*, Brady, are given as synonyms.

Cythere convexa is met with pretty abundantly all round the British coasts from low-water mark downwards. It is rare on the coast of Norway, but is common further southwards, as far as the Bay of Biscay and the Mediterranean.

Distribution.—Lervig, Stordoen, Norway, a single specimen; Fosse de Cap

Breton, Bay of Biscay, 25–60 fathoms; Naples (A. M. N.); Vigo, St. Malo; Hellespont, Beyrout, Jaffa, Latakié (G. S. B.); Messina (Seguenza).

Fossil.—Scotland, Ireland, Sicily, Calabria (Seguenza).

24. *Cythere speyeri*, G. S. Brady.

(Plate XVII., figs. 16, 17.)

1868. *Cythere speyeri*, Brady, Ann. Mag. Nat. Hist. ser. IV., vol. ii., p. 222, pl. xv., figs. 8–11.
1868. *Cythere speyeri*, Brady, Les Fonds de la Mer., vol. i., p. 99, pl. xii., figs. 8–10.
1880. *Cythere speyeri*, Brady, "Challenger" Report, p. 79, pl. xx., figs. 2 *a–p*.

Shell of the female excessively tumid. Seen from the side, broadly ovate, with a prominent posterior beak; greatest height in the middle, and equal to two-thirds the length; anterior extremity fully rounded, and forming a continuous curve with the dorsal margin, which is boldly arched; posterior extremity produced below the middle into a prominent angular beak; ventral margin moderately convex. Seen from above, the outline is broadly ovate, not twice as long as broad, widest behind the middle, lateral margins extremely convex, converging gently towards the front and more abruptly backwards; anterior extremity subacuminate, posterior obtuse. End view broad, ovate, widest below the middle, pointed at the apex, sides very convex. Left valve larger than the right. Surface of the shell marked throughout with large circular inpressed puncta; hinge tubercles conspicuous; no very marked encircling fillet. Length, ·9 mm.

Distribution.—Bay of Biscay, Marquis de Folin; Tenedos, Colon, New Providence, St. Vincent, Cape Verd; and by the "Challenger" Expedition at the last-named locality, in 1070 to 1150 faths. (Stat. 93), and off Ascension Island (Stat. 344), 420 fath. (G. S. B.); off Capri, Bay of Naples, 40 fath. (A. M. N.).

This species may be distinguished from *C. convexa* by its excessive tumidity. Fine living specimens have the anterior margin and the posterior rostrate process beset with minute spinules, and on the ventral margin, at the posterior extremity, is a small spine. The posterior tubercles and spine are shown in the figure given in the "Annals," and this figure most characteristically represents the species.

25. *Cythere marginata*, Norman.

1868. *Cythere marginata*, Brady, Mon. rec. Brit. Ostrac., p. 413, pl. xxxi., figs. 5–8.
1868. *Cythere laticarina*, Brady, Mon. rec. Brit. Ostrac., p. 412, pl. xxxi., figs. 1–4.
1874. *Cythere laticarina*, Brady, Crosskey, and Robertson, Mon. Post-tert. Entom., p. 158, pl. ix., figs. 23–26.

The type of *C. marginata* was an aged and worn specimen, which, since we have had opportunities of studying larger series of forms, we find to be the same as the more recently described *C. laticarina*.

Additional localities.—Scilly Islands, Birturbuy Bay (G. S. B. and D. R.); off Tarbert, Loch Fyne, 25 fathoms; Salcombe, Devon (A. M. N.); four miles east of Gobbins, Irish Channel, in 60 fathoms (Malcomson).

Distribution.—Fosse de Cap Breton, 100 fathoms; Spitzbergen (G. S. B.); Lervig Bay, Hardanger Fiord, Norway (A. M. N.).

Fossil.—Raised Beach, Oban, Scotland.

26. *Cythere jeffreysii*, Brady.

1868. *Cythere jeffreysii*, Brady, Mon. rec. Brit. Ostrac., p. 412, pl. xxix., figs. 51–55.
1874. *Cythere jeffreysii*, Brady, Crosskey, and Robertson, Mon. Post-tert. Entom., p. 156, pl. iii., figs. 18, 19.

Additional locality.—Dredged off Penarth Head, South Wales (G. S. B. and D. R.).

Fossil.—Raised Beach, Oban, Scotland.

27. *Cythere limicola*, Norman.

Synonyms.—*C. nodosa*, G. O. Sars; *C. areolata*, Brady.

1868. *Cythere limicola*, Brady, Mon. rec. Brit. Ostrac., p. 405; pl. xxxi., figs. 38–41 (*at non*, figs. 43–46).
1874. *Cythere limicola*, Brady, Crosskey, and Robertson, Mon. Post-tert. Entom., p. 154, pl. x., figs. 1–4.
1878. *Cythere limicola*, Brady, Ostracoda, Antwerp Crag, Trans. Zool. Soc., vol. x., p. 389, pl. lxiv., figs. 9 *a–b*,

This is certainly one of the least common of the British Cytheres.

Additional localities.—The Minch; in 25 fathoms in the channel between the greater and lesser Islands of Cumbrae, in the Firth of Clyde (A. M. N.); one

mile off the Gobbins, in the Irish Channel, 15–18 fathoms; Belfast Lough, 6–10 fathoms (Malcomson). This species seems to be more abundant and finer in growth on the north-east coast of England than in any other locality.

Distribution.—Norway; very rare, Lofoten Islands, and "sinus Nidaroensis," 6–10 fathoms (G. O. Sars); Baffin's Bay (G. S. B.).

Fossil.—Scotland, Canada.

28. *Cythere cuneiformis*, Brady.

Synonym: *Cythere ventricosa*, G. O. Sars.

1868. *Cythere cuneiformis*, Brady, Mon. rec. Brit. Ostrac., p. 404, pl. xxxi., figs. 47–54.

1874. *Cythere cuneiformis*, Brady, Crosskey, and Robertson, Post-tert. Entom., p. 154, pl. x., figs. 23–26.

This is a widely and generally distributed species, on the British coasts, though found always very sparingly. For the most part it inhabits depths of 15–40 fathoms; but it occurs in several shallow estuarine localities in Northumberland, and has once been found between tide-marks on mud-covered rocks at Whitley, Northumberland (G. S. B.).

Distribution.—Lervig, Stordöen, Norway (A. M. N.); Dröbak and Langesund, Norway (G. O. Sars).

Fossil.—Scotland, Norway.

29. *Cythere navicula*, Norman.

(Plate xvi., figs. 15, 16.)

1868. *Cytherura navicula*, Norman, Last Report Dredging among the Shetland Isles, Brit. Assoc. Report, p. 292.

1870. *Cythere fidicula*, Brady and Robertson, Ann. and Mag. Nat. Hist., ser. iv., vol. vi., p. 21, pl. viii., figs. 8–11.

Shell, as seen from the side, trapezoidal; height equal to not much more than one-third of the length; extremities narrowly rounded below, about their middle sloping at both extremities obliquely upwards to join the short and straight dorsal margin, which they join at an obtuse angle; ventral margin almost straight, but slightly protruded in front of the middle as a rounded tubercular prominence. Behind the middle there is sometimes another pair of similar tubercular processes, but these are smaller and less pronounced. Seen from above, elongated, subhexagonal, with parallel sides, and obtuse or subtruncated extremities; the two anterior angles well-marked, the posterior rounded off; width equal to the height. Seen from below,

the ventral surface exhibits at its anterior angles two prominent rounded eminences, behind which it becomes slightly constricted, again swelling out into a convex margin behind the middle (where there is sometimes another pair of rounded eminences). End view subtriangular, apex rounded off, basal angles prominent and sharp, sides convex, base slightly concave. Shell marked with irregular and sinuous longitudinal raised lines, which on the concave ventral surface are especially conspicuous. Length, ·65 mm.

This is a very remarkable species. Dr. Norman placed it in *Cytherura*, but we are now agreed that its nearest ally is perhaps *Cythere cuneiformis*, of which Professor G. O. Sars has examined the animal, and found it to be a Cythere.

Dr. Brady, in his original description, was struck by the contour of the shell, as seen from below, as being "remarkably fiddle-shaped," and from this circumstance chose his specific name. On the other hand, it presented to Dr. Norman's imagination another figure, and he wrote "Ventral aspect, boat-shaped, the resemblance most striking; centrally depressed at the juncture of the valves; bows moderately sharp, of good breadth of beam, sculptured with raised, thread-like concentric lines, representing the timbers, while the small nodulous processes stand for the thole-pins. The dorsal and end views bear out the allusion, the former representing a boat viewed from below, with a well-marked keel, and the latter being triangular, with gently-rounded sides." Hence he adopted the specific name, "*navicula*."

This species has now been found in many localities, but is remarkably rare numerically, one or two specimens at each place being all that have been met with.

Papa, Shetland; Budle Bay, Northumberland; estuary of Thames; Roundstone, Ireland; inside St. Mary's, Scilly (G. S. B. and D. R.); St. Magnus' Bay, Shetland, 30–60 fathoms; the Minch; Salcombe, Devon; Birturbuy Bay, Ireland (A. M. N.).

Distribution.—Estuaries of the Scheldt and Meuse, Holland (G. S. B.); off Sartoro, in Bergen Fiord, Norway, 15 fathoms, one specimen (A. M. N.).

30. *Cythere globulifera*, Brady.

1868. *Cythere globulifera*, Brady, Mon. rec. Brit. Ostrac., p. 406, pl. xxxi., fig. 42.

1874. *Cythere globulifera*, Brady, Crosskey, and Robertson, Mon. Post-tert. Entom., p. 155, pl. ix., figs. 18–20, and (?) 21, 22; pl. xii., figs. 11, 12; plate xv., figs. 19, 20.

This appears to be an extremely rare form in a recent state.

Additional locality.—Two miles S.S.E. of Maidens Lighthouse, Irish Channel, in 62 fathoms (Malcomson).

Distribution.—Stoksund, near the mouth of the Hardanger Fiord, Norway, in 126 fathoms (A. M. N.); Spitzbergen, Cape Frazer, 50–80 fath., Capt. Feilden's dredgings (G. S. B.).

Fossil.—Scotland, England (Bridlington), Canada.

31. *Cythere cluthæ*, Brady, Crosskey, and Robertson.

(Plate XIV., figs. 25–27, vol. XVII., figs. 35, 36.)

1874. *Cythere cluthæ*, Brady, Crosskey, and Robertson, Mon. Post-tert. Entom, p. 153; pl. xiii., figs. 16, 17.

1886. *Cythere cluthæ*, Malcomson, Recent Ostracoda of Belfast Lough (Proc. Belfast Nat. Field Club), p. 260.

Shell, as seen from the side, subquadrate; highest in front; greatest height equal to more than half the length; anterior extremity broad and well-rounded; posterior narrow and subtruncate, only slightly rounded; superior margin almost straight, sloping from before backwards; inferior slightly sinuated in the middle. Seen from above, the outline is oblong, subrectangular, with parallel irregularly sinuous sides, tapered off towards the front, which is truncated; posterior extremity irregularly rounded. Shell-surface irregularly mamillated, closely set with small subrotund pittings. The valves are encircled by a broad, swollen marginal lip, the central portion being elevated and very uneven. Length, ·35 mm.

The late Mr. Malcomson says of this species, that "although rare, it seems to be generally distributed in the deeper water" of the Irish Sea and Belfast Lough. He gives the following localities:—First, in the Irish Channel, 2–5 miles S.S.E. of Maidens Lighthouse, 60–72 fathoms; half a mile off Coalpit Bay, 13 fathoms. Secondly, in Belfast Lough, off White Head, 10–18 fathoms. We are indebted to Mr. T. Scott for specimens dredged in about 20 fathoms in Loch Fyne. From one of these specimens our descriptions and illustrations are drawn up.

Distribution.—Cape Frazer, 80 fath. in Capt. Feilden's dredgings, Nares' Arctic Expedition (G. S. B.).

Fossil.—Scotland.

32. *Cythere complexa*, G. S. Brady.

(Plate XIX., figs. 31, 32.)

1866. *Cythere complexa*, Brady, On Ostracoda dredged amongst the Hebrides (Brit. Assoc. Report), p. 210.

1866. *Cythere limicola (partim)*, Brady, Mon. Brit. Ostrac., p. 405, pl. xxxi., figs. 43–46.

Shell, seen laterally, rhomboidal, a little higher in front than behind; height equal to more than half the length; anterior extremity obliquely truncated, rounded

off below and obscurely angulated above; posterior very oblique, truncated, forming a projecting beak above the middle, postero-dorsal angle broadly and obliquely truncated, emarginate; dorsal margin almost rectilinear, ventral gently convex. Seen from above, the outline is subhexagonal, the margins very irregular, strongly and sharply mucronate behind and very obtuse in front; greatest width equal to the height, and situated behind the middle; lateral margins very deeply excavated in the middle, converging sharply towards the front, and still more abruptly behind. Surface of the valves irregularly waved and rugose, bordered in front by a broad encircling flange, and near the posterior extremity sinking suddenly in a transvere direction, thus forming with the ventral margin a rectangular ridge. Length, ·4 mm.

Originally described from specimens dredged by the late Dr. Jeffreys and A. M. N. in the Minch. It has been more recently dredged by Dr. Norman in a depth of 126 fathoms at Stoksund, Norway.

33. *Cythere villosa* (G. O. Sars).

1868. *Cythere villosa*, Brady, Mon. rec. Brit. Ostrac., p. 411, pl. xxix., figs. 28–32.

1874. *Cythere villosa*, Brady, Crosskey, and Robertson, Mon. Post-tert. Entom., p. 157, pl. iii., figs. 7–13.

1888. *Cythereis emarginata*, Dahl, Die Cytheriden der Westlich. Ostsee., p. 13, pl. i., figs. 13–26, 30.

One of the most abundant and most widely-distributed of the British marine species, ranging for the most part from low water to about 40 fathoms. Many new localities might be added to those given in the "Monograph." It is, in fact, scarcely ever absent either from dredgings or from littoral shell sand.

Distribution.—In Norway it has been dredged in from 3–180 fathoms, Bergen; off Sartoro, near Bukken; Lervig Bay, Stordöen; Stoksund (A. M. N.). Holland, River Scheldt; Davis Strait, Lat. 67° 17′ N., Long. 62° 21′ W, six feet below low-water mark (G. S. B. and D. R.), Iceland; Bay of Biscay (G. S. B.).

Fossil.—England, Scotland, Ireland, Canada.

34. *Cythere pulchella*, Brady.

(Plate xv., figs. 7, 8).

1868. *Cythere pulchella*, Brady, Mon. rec. Brit. Ostrac., p. 404.

1868. *Cythere pulchella*, Brady, Ann. and Mag. Nat. Hist., ser. iv., vol. ii., p. 32, pl. v., figs. 18–20.

1869. *Cythere pulchella*, Brady and Robertson, Ann. and Mag. Nat. Hist., ser. iv., vol. iii., p. 369, pl. xx., figs. 1–3.

1874. *Cythere pulchella*, Brady, Crosskey, and Robertson, Mon. Post-tert. Entom., p. 157, pl. iii., figs. 29–37.

Additional localities.—Firth of Forth, Stromness, and Loch Ryan (D. R.); Kilchattan Bay, Isle of Bate; Kames Bay, Isle of Cumbrae; off Ilfracombe; Birturbuy,

Clifden, and Westport Bays, Ireland (G. S. B. and D. R.); Filey Brig, Yorkshire; Dartmouth Harbour (A. M. N.); Irish Channel and Belfast Lough (Malcomson).

Distribution.—Holland, river Scheldt; Davis Strait, Lat. 67° 17′ N., Long. 62° 21′ W., six feet below low-water mark (G. S. B. and D. R.).

Fossil.—Scotland, Ireland.

35. *Cythere borealis*, Brady.

(Plate xv., figs. 18, 19.)

1868. *Cythere borealis*, Brady, Ann. and Mag. Nat. Hist., ser. iv., vol. ii., p. 31, pl. iv., figs. 1–4, 6, 7.

Shell of female, seen laterally, subreniform; highest in front of the middle; greatest height equal to half the length; anterior extremity very deep, obliquely rounded; posterior subtruncate, somewhat emarginate above the middle, below this emargination the shell slopes obliquely forward without curvature to meet the inferior margin; dorsal margin gradually declining with a gentle sweep backwards from the highest point of the shell in front of the middle; ventral margin incurved centrally, and pouting in front. Outline, as seen from above, long-ovate, widest in the middle; extremities equal, obtuse; width about equal to half the length. The right valve differs from the left in shape, being higher with the dorsal margin more boldly arched, distinctly excavated in front, and much more conspicuously emarginate behind. The hinge groove in the united valves, as seen from above, is very wide and deep; the hinge joint is formed, in the left valve, by a crenulated median bar, with a moderately strong anterior tooth, in the left valve by an anterior tooth and a slightly crenulated posterior projection. The shell of the male is longer and narrower, with the anterior margin produced downwards, and numerously serrated. Surface of the valves covered with shallow, rounded impressions, but not at all rugose or tuberculated. Colour, yellowish-brown, or purplish. Antennules robust, six-jointed, fourth and fifth joints coalescent; last four armed with strong, flexuous, apical spines, flagellum of antennæ in the female short and robust. Feet long and strong; second joint of last foot shorter than the two succeeding joints, terminal claws long and pectinated on the concave border. Male copulative organs of moderate size; posterior segment obtusely triangular. Length, 1 mm.

This species is nearly related to *C. emarginata* (G. O. Sars), but is altogether destitute of the peculiar angulated ridge which runs across the hinder portion of the valves in that species; the surface markings are also less sharply cut, and less angular. It is still more closely related to *C. villosa*, and indeed looks very like a strongly developed and much larger form of that species; but while the general outline of the shell is very like that of the two species to which we have referred,

the extension or oblique backward slope at the infero-posteal corner is peculiarly characteristic of the present species.

The young are still deeper in proportion in front than the adult, and the surface-sculpture at that age more resembles punctation.

The only British Station in which this species has been found is at Seaton-Carew, in the County of Durham, on mud-covered rocks, near low-water mark (G. S. B.).

Distribution.—Davis' Strait, lat. 67° 17′ N., long. 62° 21′ W. (Dr. Sutherland); Holstenbourg Harbour, 10 fathoms; Godhaven, 5–25 fathoms; lat. 69° 31′ N., long. 56° 1′ W., muddy bottom, 100 fathoms, "Valorous" Exped. (A. M. N.). Dobbs' Bay, 79° 35′ N., 46 fathoms, Captain Feilden's dredgings in Nares' Arctic Expedition (G. S. B.).

The types of *C. borealis* were those found in Davis' Strait by Dr. Sutherland, as above mentioned; they occurred six feet below low-water mark. From one of these specimens our illustrations are drawn.

36. *Cythere fuscata*, Brady.

(Plate xv., figs. 9–11.)

1868. *Cythere fuscata*, Brady, Ann. and Mag. Nat. Hist., ser. iv., vol. iii., p. 47, pl. vii., figs. 5–8.

Length of *female*, ·60 mm.; of *male*, ·75 mm. Shell of the *male*, seen laterally oblong, subreniform; rather higher in front than behind; height equal to half the length; anterior extremity boldly rounded, posterior slightly emarginate above the middle; superior margin almost straight, inferior rather deeply sinuated in the middle. Seen from above the outline is oblong-ovate, with nearly parallel sides, and nearly twice as long as broad; acutely pointed in front, broadly rounded or subtruncate behind. Surface of the valves closely and finely punctate; colour, yellowish-brown. The shell of the *female* is much smaller, and higher in proportion to the length.

This is a very distinctly-marked species, and so far as we at present know, is confined to estuarine and brackish or sub-brackish situations in Holland and the East of England. The British Stations in which we have found it are as follow:—Horsey Mere; Hickling, Ormesby and Oulton Broads; Breydon Water; Rivers Ouse (Norfolk), Bure, Deben, Thames (G. S. B. and D. R.).

Distribution.—Holland, Rivers Scheldt and Maas, Mr. Davison (G. S. B. and D. R.).

37. *Cythere macchesneyi*, Brady and Crosskey.

(Plate xvii., figs. 30, 31.)

1871. *Cythere mac chesneyi*, Brady and Crosskey, Geological Magazine, vol. viii., p. 4, pl. ii., figs. 1, 2.

Shell, seen from the side, compressed, subreniform ; greatest height in front, and equal to half the length ; the anterior extremity evenly rounded, posterior narrower and obliquely rounded; dorsal margin straight, sloping from before backwards, and slightly angular at each end; ventral margin deeply sinuated in the middle. Seen from above, ovate, widest in the middle, width rather less than the height; sides subparallel, converging abruptly towards the front, which is bluntly pointed, rounded off behind. Surface thickly set with small circular impressions arranged somewhat concentrically ; ventral surface furrowed. Length, ·5 mm.

Distribution.—Shore sand, the Berg Beach, lat. 82° 29′ N., Captain Feilden's dredgings in Nares' Arctic Expedition (G. S. B.).

Fossil.—Post-tertiary deposits, Montreal and Saco, North America.

38. *Cythere septentrionalis*, Brady.

(Plate xvi., figs. 13, 14.)

1866. *Cythere septentrionalis*, New and imperfectly-known Marine Ostracoda, Trans. Zool. Soc., vol. v., p. 375, pl. lx., figs. 4 *a–f*.

Shell oblong, subquadrilateral, very tumid; height equal to half the length, or, in male, less; anterior margin broad and obliquely rounded; posterior narrower, subtruncate ; dorsal margin nearly straight, with a slight convexity in the middle, and sloping gently backwards to the posterior hinge; ventral margin slightly sinuated in front of the middle. Seen from above ovate, very tumid, width equal to height, extremities very obtusely rounded. End view nearly round, the breadth exceeding the height. Ventral aspect flattened, wide, longitudinally grooved. Valves sculptured with angular cells, which gradually coalesce towards the margin, forming there larger spaces, which take the form, on the ventral surface, of sharply-cut, longitudinal furrows. The reticulated sculpture prevails on the central parts of the dorsal and lateral aspects ; but over the whole ventral surface longitudinal grooving only is visible. Length, 1·4 mm.

Distribution—A remarkably fine species, of which many specimens were found in Dr. P. C. Sutherland's dredgings at Hunde Islands, Baffin's Bay, in 60–70 fath. (G. S. B.).

39. *Cythere echinata* (G. O. Sars).

(Plate xvi., figs. 9, 10.)

1865. *Cythereis echinata*, G. O. Sars, Oversigt of Norges Ostracoder, p. 44.
1866. *Cythere catenata*, Brady, New and imperfectly known Marine Ostracoda, Trans. Zool. Soc., vol. v., p. 374, pl. lx., figs. 2 *a–d*.
1880. *Cythere irpex*, Brady, Report "Challenger" Ostracoda, p. 107, pl. xvii., figs. 2 *a–d*.
1886. *Cythere monacantha*, Brady, Les Fonds de la Mer, vol. iv., p. 197, pl. xv., figs. 5, 6.

Shell, seen from the side, subovate, or inclining to subquadrangular, short and high; remarkable for the position and character of the greatest tumidity, which consists of a gradual swelling-up of the shell (without any augularity or excrescesces) to a point situated a little within the ventral margin on the posterior half of the shell; height equal to nearly two-thirds of the length; anterior extremity higher than posterior, very widely and evenly rounded, the margin flattened, and crenulated or spined; posterior extremity subtruncate, and slightly emarginate above, the margin flattened, and crenulated or spined, two spines on the infero-posteal corner (if perfect) are larger than any others on the shell; dorsal margin, at first, very prominent, and angled, then slightly concave, and lastly convex; ventral margin showing very slight trace of sinuation. Seen from above, ovate; greatest breadth situated a little behind the middle and equalling the height; margins evenly arched, the anterior extremity much more drawn out than the hinder. Surface of valves covered with very numerous slender spines, which when the shell is perfect appear to be arranged in regular concentric lines, although in worn specimens the sculpture of the surface is found to be reticulated; the spines along the dorsal margin, two or three at the infero-posteal corner, and one or two at the higher portion of the greatest tumidity are generally larger than the rest. Length, 1 mm. to 1·25 mm.

Sars describes the animal:—"No eyes. Colour, pale brownish-yellow. All the limbs elongated and slender, yellow. Upper antennæ distinctly six-jointed, last joint long and slender, about equal to the combined length of the two preceding, ending in three spiniform setæ; lower antennæ slender, with greatly elongated terminal nails; flagellum very short. Mandibular palp having the last two joints very elongated, the last extremely narrow and curved; branchial appendage furnished with five setæ, the outer two of which are rudimentary. Feet very slender, last pair having the second joints about equal in length to the two following. Basal portion of the copulatory organ of the male subtriangular, the extremity elongated-ovate, and bent inwards."

Distribution.—In Norway rare in 30–100 fathoms Christiania Fiord, extending northwards to the Lofoten Islands, where it is found in 300 fathoms (G. O. Sars): Dröbak, 30–100 fathoms; Hardanger Fiord, off Midso Lighthouse, 210 fathoms; Bergen Fiord, south of Bukken, 150–200 fathoms; Oster Fiord, 375 fathoms: "Porcupine," 1869, Stat. 19, lat. 54° 53′ N., long. 10° 56′ W., 1360 fathoms; Stat. 41, lat. 49° 4′ N., long. 12° 22′ W., 582 fathoms: "Valorous" Exped., 1875, Stat. 12, lat. 56° 11′ N., long. 37° 41′ W., 1450 fathoms (A. M. N.). "Challenger" Exped., Stat. 73, lat. 38° 30′ N., long 31° 14′ W., 1000 fathoms; Stat. 78, lat. 37° 34′ N., long. 25° 13′ W., 1000 fathoms; Stat. 335, lat. 32° 24′ S., long. 13° 5′ W., 1425 fathoms (G. S. B.).

The types of Dr. Brady's *C. catenata* were found in M'Andrew and Barrett's Norwegian dredgings, and they unquestionably represent the young of this species.

40. *Cythere acanthoderma*, Brady.

1866. *Cythere scabra*, Brady, New and imperfectly-known Marine Ostracoda, Trans. Zool. Soc., vol. v., p. 380, pl. lxi., figs. 8 *a–d* (*non* Münster).

1880. *Cythere acanthoderma*, Brady, Report "Challenger" Ostracoda, p. 104, pl. xviii., figs. 5 *a–e*.

1885. *Cythere acanthoderma*, Carus Prod. Faunæ Medit., p. 300.

Shell oblong, subovate, tumid, the greatest tumidity on the posterior half of the shell a little within the ventral margin; in the adult covered everywhere with more or less strongly developed, very irregular, blunt and rugged spines. Seen from the side the valves are subovate or somewhat pear-shaped, highest near the front, the height being equal to nearly two-thirds the length; anterior extremity well and broadly rounded; posterior narrower and also rounded, being most produced in the middle; dorsal margin sloping backwards evenly from the front hinge, its margin very much laciniated into spiny processes; ventral margin slightly convex. Seen from above, the outline is subovate, not twice as long as broad, widest near the middle; sides curved, converging gradually towards the front, but abruptly behind; extremities wide and truncated. The end view is subtriangular, equilateral, with convex sides and rounded angles. The margins of the shell, from whatever aspect it is viewed, are excessively rugged, and the spines with which it is everywhere thickly beset, have a tendency to enlarge and become bifurcate or trifurcate at their apices, a very remarkable character which enables it at once to be distinguished from many allied forms, as for example, from *C. dasyderma* in which the spines are invariably simple. There are certain spines in the present species which usually assume a greater development than the rest, namely, one or two over the hinge, and especially one at the distant termination of the dorsal margin, and one

at the hinder termination of a ridge which runs along the most tumid portion of the shell, a little way within the ventral margin.* Length 1 to 1·25 mm.

Young specimens have the shell in a great measure smooth, the first spines developed being those which surround the margin, and those which crown the ridge passing along the most tumid portion of the shell; the bifurcation of the spines will be found to be a helpful character in the determination of these early stages.

Distribution.—"Porcupine" Exped., 1869, Stat. 19, lat. 50° 53′ N., long. 10° 56′ W., 1360 fathoms; "Valorous" Exped., 1875, Stat. 12, lat. 56° 11′ N., long. 37° 41′ N., 1450 fathoms; Stat. 16, lat. 55° 10′ N., long. 25° 58′, 1785 fathoms (A. M. N.). One of the "Challenger" Stations comes within the area to which this paper specially applies, Stat. 64., lat. 30° 35′ N., long. 50° 27′ W., 2750 fathoms; it was met with in six other "Challenger" Stations, in depths ranging from 580 to 2050 fathoms, midway between the Cape of Good Hope and Kerguelen Island, to the north of Australia, and in both North and South Pacific (G. S. B.), Messina, Sicily (Seguenza), Abrolhos; Crete, 360 fathoms, Cap. Spratt (G. S. B.).

Fossil.—Sicily (Seguenza).

41. *Cythere dictyon*, Brady.

1880. *Cythere dictyon*, Brady, Report "Challenger," Ostracoda, p. 90, pl. xxiv., figs. 1 *a–y*.

Shell of the female, seen from the side, oblong, quadrangular, not much higher in front than behind, height equal to more than half the length; anterior extremity well rounded, fringed below the middle with numerous short teeth; posterior subtruncated, scarcely rounded, irregularly toothed on the lower half; the dorsal margin sloping gently from before backwards, and always, in adult specimens, more or less irregularly jagged, while in some cases the indentations are remarkably deep; ventral margin more or less convex. Seen from above the outline is lozenge-shaped or somewhat hastate, about twice as long as broad, sides subparallel or converging gently towards the front, extremities broad and truncated. End view triangular, with convex margins and rounded angles. Shell-surface covered with an irregular network of ribs, the main lines of which have often an obscurely radiate arrangement, originating in an obsolete central tubercle; just within and parallel with the ventral margin is a prominent, sharply-cut ridge, which is often produced beyond the middle of the valve into a strong spine, but is continued in a less prominent style round the anterior and posterior portions of the shell, thus enclosing an

* In old and ragged examples, such as those figured in the "Challenger" Report, the spines and ridge, to which attention is here called, lose their prominence, owing to the great development of all the other spiny processes.

elevated central area. The shell of the male has usually a more strongly-developed spinous armature than is seen in the female. Length 1·0 mm.

Distribution.—*Cythere dictyon* is almost ubiquitous in the greatest depths of the ocean, and was found by Dr. Brady, in sands from no less than twenty-four stations, extending over the North and South Atlantic, the Indian and Pacific Oceans. The shallowest water in which it has been known is Humboldt Bay, Papua, in 37 fathoms. In fifteen stations it was found in depths which exceeded 1000 fathoms, and three of these were below 2000 fathoms.

Six "Challenger" Stations were within the range of the present Paper, that is, in the North Atlantic, north of latitude 35° N. They were as follows:—Stat. 64, lat. 35° 35′ N., long. 50° 27′ W., 2790 fathoms; Stat. 70, lat. 38° 25′ N., long. 35° 50′ W., 1675 fathoms; Stat. 73, lat. 38° 30′ N., long. 31° 14′ W., 1000 fathoms; Stat. 75, lat. 38° 37′ N., long. 28° 30′ W., 450 fathoms; Stat. 76, lat. 37° 34′ N., long, 25° 13′ W., 1000 fathoms; Stat. 78, lat. 37° 24′ N., long. 25° 13′ W., 1000 fathoms. These dredgings constitute a line commencing about half-way between the Bermuda Islands and the Azores, and extending thence to the latter islands (G. S. B.).

This, and *C. dasyderma* and *C. acanthoderma*, have an enormous geographical range, apparently ranging throughout the world in the great ocean abysses.

42. *Cythere dasyderma*, Brady.

1880. *Cythere dasyderma*, Brady, Report "Challenger" Ostracoda, p. 105, pl. xvii., figs. 4 *a–f*; pl. xviii., figs. 4 *a–f*.

1885. *Cythere dasyderma*, Carus. Prod. Faunæ Mediterraneæ, p. 300.

Shell tumid; seen from the side oblong, subovate or subquadrangular; greatest height situated near the front, and equal to about two-thirds of the length; anterior extremity boldly rounded; posterior narrower, rounded or subtruncate; dorsal margin sloping gently backwards from the front, which is elevated over the hinge joint; ventral margin slightly convex; the entire circumference broken into closely-set, but short and blunt teeth. Seen from above the outline is ovate, widest near the middle, about twice as long as broad, lateral margins gently and evenly curved, extremities broad, and nearly equal, obtusely rounded or truncated. End view broadly ovate, rounded off above, and centrally emarginate below. Surface of valves with closely-packed rather small angular excavations, from the intervals between which arise numberless (usually short and blunt) spines, the shell in every aspect presenting a rough appearance. Length ·65 to ·9 mm. In some specimens the spines are arranged in three or four rows anteriorly, and within the ventral margin in

two distinct lines, in other examples the arrangement in these parts as elsewhere is confused.

Distribution.—"Porcupine" Exped., 1869 Stat., 19, lat. 54° 53′ N., long. 10° 56′ W., 1360 fathoms: "Valorous" Exped., 1875, Stat. 12, lat. 56° 11′ N., long. 37° 41′ N., 1450 fathoms; Stat. 13, lat. 56° 1′ N., long. 34° 42′ N., 690 fathoms (A. M. N.). In the "Challenger" Exped. *Cythere dasyderma* was found in no less than twenty dredgings from the North and South Atlantic, North and South Australia, New Zealand, and North and South Pacific (almost to Cape Horn). The only station in the district to which this Paper has special reference was Stat. 70, lat. 38° 25′ N., long. 35° 50′ W., 1675 fathoms. The least depth in which it has been found was at Stat. 167, lat. 39° 32′ S., long. 171° 48′ E., 150 fathoms. The following are the greatest depths:—Stat. 5, lat. 24° 20′ N., long. 24° 28′ N., 2740 fathoms; Stat. 246, lat. 36° 10′ N., long. 178° 0′ E., 2050 fathoms; Stat. 332, lat. 37° 29′ S., long. 27° 31′ W., 2200 fathoms; Stat. 346, lat. 2° 42′ S., long. 14° 41′ W., 2350 fathoms (G. S. B.). Seguenza has found it in the Mediterranean at Messina.

Fossil.—Sicily (Seguenza).

43. *Cythera scabrocuneata*, Brady.

(Plate xv., figs. 28, 29.)

1880. *Cythere scabrocuneata*, Brady, Report "Challenger" Ostracoda, p. 103, pl. xvii., figs. 5 *a–f*; pl. xxiii., figs. 2 *a–c*.
1880. *Cythere dorsoserrata*, Brady, *ibid.*, p. 102, pl. xxiii., figs. 1 *a–d*.

Shell of the female, seen from the side, in shape as a long triangle, with the apex behind, greatest height in front, less than or equal to half the length, anterior extremity broad, well rounded; posterior much narrower, and produced slightly below the middle to a conspicuous point; dorsal margin generally gibbose over the hinge, thence gradually sloping backwards; ventral margin arcuate in front, slightly sinuated about the middle, and behind this, gently curved and converging equally with the dorsal towards the posterior extremity; a flattened fillet borders the ventral and more markedly the anterior and posterior margins, and this, together with the dorsal margin, is more or less toothed or jagged. Seen from above the outline is ovate, twice as long as broad, in front broadly rounded, behind somewhat hastate. Surface of valves thickly covered with nodulous elevations, which when perfect terminate in short, blunt, spiny points; on the other hand, when the nodules are themselves rubbed away, the surface is found to be reticulated, being sculptured with round or hexagonal cells. Length, ·77 mm.

Distribution.—"Porcupine" Exped., 1869, Stat. 19, lat. 54° 53′ N., long. 10° 56′ W., 1360 fathoms; "Valorous" Exped., 1875, Stat. 12, lat. 59° 11′ N., long. 37° 41′ W., 1450 fathoms (A. M. N.). Côtes des Landes, Bay of Biscay, Marquis de Folin (G. S. B.). Dredged in the "Challenger" Expedition, Stat. 162, off East Moncœur Island, Bass' Straits, in 38–40 fathoms; Stat. 233 *b*, in Inland Sea, Japan, lat. 34° 20′ N., long. 133° 35′ E., 15 fathoms, and Wellington Harbour, New Zealand.

44. *Cythere trispicata*, n. sp.

(Plate XVI., figs. 5, 6.)

Shell, seen from the side, narrowly oblong, greatest height posterior, equal to about two-fifths of the length; dorsal and ventral margins nearly straight and subparallel, very slightly converging forwards from the highest point, which is near the posterior extremity; anterior margin narrow, obliquely truncated; posterior margin broad, obliquely truncate, sharply angulated both above and below. Seen from above, the extremities are greatly compressed, while the central portion swells out to give support to the three long spikes—presently to be described—which are projected divergently like the prongs of a trident. Surface of valves furnished with numerous blunt tuberculations, the most conspicuous of which pass in series round the margins of the valves at both extremities; central portion of valves swollen and supporting three very remarkable spike-like projections; the anterior of these is the longest, and is directed forwards, its height being equal to about half the length of the shell; the central is of similar shape but shorter, while the posterior, which is a little behind the middle, is much thicker, transversely flattened, and shorter than the others. Length about ·5 mm.

This is a most remarkable form, totally different to all species, recent or fossil, known to us. The nearest approach to it is perhaps to be found in *Cythere umbonata*, Williamson, as figured by Marsson ("Die Cirripedien und Ostracoden der weissen Schreibkreide der Insel Rügen," pl. III., fig. 15), rather than the figures of earlier authors; the outline is of similar type, and there is one spike near the extremity of the valves.

The single specimen here described has been kindly sent to us for description by the Marquis de Folin, who found it on the coast of Les Landes, south-west of France.

45. *Cythere latimarginata*, Speyer.

(Plate xv., figs. 16, 17.)

1863. *Cythere latimarginata*, Speyer, Die Ostrac., der Casseler Tertiarbild, p. 22, pl. iii., figs. 3 *a–d*.
1865. *Cythereis abyssicola*, G. O. Sars, Oversigt af Norges Ostracoder, p. 43.
1868. *Cythere abyssicola*, Norman, Last Report Dredging among Shetland Isles (Brit. Assoc. Report), p. 290.
1874. *Cythere abyssicola*, Brady, Crosskey, and Robertson, Post-tert. Entom., p. 163, pl. xvi., fig. 6.
1878. *Cythere abyssicola*, Brady, Ostracoda Antwerp Crag, Trans. Zool. Soc., vol. x., p. 389, pl. lxiv., figs. 8 *a–d*.)

Shell of *female*, seen laterally, oblong, subquadrate, greatest height situated in front and equal to more than half the length; anterior extremity broadly and obliquely rounded, and bordered with a series of minute teeth, which are continued round the ventral angle; posterior much narrower, obliquely truncated, and emarginate in the middle, and often having four or five small teeth towards the inferior angle; dorsal margin sinuated in the middle, and much elevated in a gibbose fashion over the anterior hinge; ventral straight, with a slight median sinuation. Seen from above, the outline is irregular, twice as long as broad, the lateral margins nearly parallel, each showing two protuberances separated from each other by an intervening hollow, extremities prominent and truncated. Valves hard and thick, distinctly areolated, and surrounded, except on the dorsal margin, by a broad, thickened band, which forms a keel-like flange, and in front is divided by a narrow furrow into two. In the middle of each valve is a prominent rounded tubercle. The shell of the *male* is narrower and more angular, but the adults of both sexes seem to be about equal in length. Colour, pale, yellowish-brown. Length, ·7 mm.

Sars thus describes this animal:—"Eyes very small, rounded. Antennæ moderately elongated, third and fourth joints of the upper pair united, the last short; third joint of lower antennæ narrower than usual, terminal nails elongated. Branchial appendage of the mandibular palp very small, bearing only two setæ, one of which is rudimentary and hamate. Feet slender, second joint of last pair subequal in length to the two succeeding joints combined, terminal nail very slender. Copulatory organs of the male small, the extremity obtusely triangular."

Habitat.—Unst Haaf, Shetland, 20–25 miles N.N.W. of Burrafirth, 100–140 fathoms (A. M. N.). A single specimen, apparently referable to this species, and possibly fossil, was found among sand dredged by Mr. E. C. Davison in the river Ouse, at Lynn (G. S. B.).

Distribution.—Dröbak, 60–120 fathoms; Lofoten Islands, down to 300 fathoms (G. O. Sars); Oster Fiord, north of Bergen, 100–200 fathoms; south of Bukken, Bergen Fiord, 150–200 fathoms; Lervig Bay, 20 fathoms; Stoksund, Hardanger Fiord, 126 fathoms; Christiania Fiord, 30–100 fathoms: "Porcupine" Exped., 1869, Stations, 74, 75, 76, between lat. 61° and 62° N., and long. 1°, 44°, and 3° 44′ W., in 267–640 fathoms; "Valorous" Exped., Lievely Harbour, Disco, Greenland, 5–20 fathoms; and Davis Strait, lat. 64° 5′ N., long. 56° 47′ W., 410 fath. (A. M. N.); Spitzbergen (G. S. B.).

Fossil.—Scotland (Oban); Cassel; Belgium (Antwerp).

46. *Cythere lepida*, n. sp.

(Plate xv., figs. 20, 21.)

Shell elongated, oblong, narrower behind, tumidity gradually increasing backwards to a little before the hinder extremity, where the convexity is greatest on the ventral side, behind this the posterior extremity is suddenly compressed; greatest height on the anterior third, equal to two-fifths of the length; anterior extremity—which is the highest part of shell—very broadly and evenly rounded, its point of greatest projection central; dorsal margin nearly straight, gradually and slightly declining backwards; ventral margin pouting in front, and slightly emarginate centrally. Viewed dorsally, cuneiform, greatest breadth near the posterior extremity, the sides converging thence evenly forwards to a blunt extremity, behind the greatest breadth the valves are abruptly and deeply constricted, and form a mucronate extremity, which is broadly truncate terminally. Valves having a massive broadly-rounded fillet (as in *C. latimarginata*) at both ends: all the rest of the surface is sculptured with hexagonal cells. Length, ·9 mm.

In some specimens short, blunt, tubercular nodules adorn the fillet, the dorsal margin, and anterior part of the valves, and in these specimens the cells are smaller, not hexagonal but very irregular, and varying in form.

In outline and fillet this species is allied to *C. latimarginata*, but is longer, while the surface sculpture and aspect from above are wholly different.

Distribution.—North Atlantic, lat. 56° 1′ N., long 34° 42′, W., 690 fath.: "Valorous" Exped., 1875; Stat. 13 (A. M. N.).

47. *Cythere hoptonensis*, Brady, Crosskey, and Robertson.

(Plate xv., figs. 26, 27.)

1874. *Cythere hoptonensis*, Brady, Crosskey, and Robertson, Mon. Post-tert. Entom., p. 168, pl. xiv., figs. 4–6.

Shell seen from the side quadrangular, higher in front than behind, greatest height equal to more than half the length ; anterior extremity wide, well rounded, and minutely crenulated, posterior much narrower and truncated, only slightly rounded ; dorsal margin sloping in an irregularly sinuous line from before backwards, gibbose at the anterior hinge ; ventral margin nearly straight. Seen from above lozenge-shaped, with very irregular convex sides and wide truncated extremities, twice as long as broad. The valves are produced into a flattened flange in front and behind, the surface very irregularly waved and ribbed and having in the centre a large rounded tubercle. Length, ·77 mm.

Dredged off Muros, Galicia, Marquis de Folin (G. S. B.).

48. *Cythere crenulata* (G. O. Sars).

(Plate xv., figs. 5, 6.)

1865. *Cythereis crenulata*, G. O. Sars, Oversigt af Norges marine Ostracoder (Vid-Selsk. Forhand), p. 39.
1868. *Cythere crenulata*, Norman, Last Report Dredging among the Shetland Isles (Brit. Assoc. Rep.), p. 291.

Shell very tumid, the width as great as the height, subquadrate, higher in front than behind, greatest height equal to, or more than half the length ; anterior extremity very wide, obliquely rounded, the margin crenulated with little points ; posterior narrower, subtruncate, and slightly emarginate, greatly depressed below the level of the rest of the shell, the infero-posteal corner much exserted, and furnished with little blunt spinules ; dorsal margin flexuous, at first elevated slightly and well rounded, then slightly concave before the middle, then nearly straight, and ultimately declining suddenly to meet the truncate posterior extremity (in the young the dorsal margin is straight) ; ventral straight, or very slightly sinuated in front of the middle. Seen from above, very wide in the middle, with nearly parallel though flexuous sides ; anteriorly narrowly truncate, posteriorly jutting outwards into blunt angles, beyond which the valves are suddenly contracted, and take the form of a beak-like truncated extremity. Surface of valves indistinctly areolated, and finely punctate anteriorly, and the

lower portion of the posterior margin thickened, and forming a double lip, the inner margin of which is crenulated, as has been already described; lateral surface uneven, a rounded knob in the middle of the valves, just in front of their centre; behind this two riblets pass backwards, one near the dorsal, and the other near the ventral margin—the latter the more conspicuous—and terminate in two projected knobs, beyond which the valves are suddenly depressed to form the posterior extremity. Length, ·75 mm.

Sars says of the animal: "Eyes very large, seen laterally elongate-elliptical, seen from above semilunar. Colour, pale yellow-brown. Antennæ as in *C. emarginata;* feet and their terminal claws more slender."

Habitat.—Rare 20–25 miles N.N.W. of Burrafirth, Shetland, in 100–140 fathoms (A. M. N.).

Distribution.—Very rare in 6–10 fathoms near Langesund, West Norway (G. O. Sars). Oster Fiord, north of Bergen, 100–200 fathoms; off Sartoro, 15–40 fath. and south side of Kors Fiord, 180 fath.; Lervig Bay, Stordoen, 10–28 fath.; Stoksund, 80–126 fath., Norway: "Valorous" Expedition, 1875, Davis Strait, lat. 64° 5′ N., long. 56° 47′ W., 410 fath., and Lievely Harbour, Disco, Greenland (A. M. N.).

49. *Cythere quadridentata*, Baird.

1868. *Cythere quadridentata*, Brady, Mon. rec. Brit. Ostrac., p. 413, pl. xxxi., figs. 19–30.

1874. *Cythere quadridentata*, Brady, Crosskey, and Robertson, Mon. Post-tert. Entom., p. 161, pl. xiii., fig. 22.

1885. *Cythere quadridentata*, Carus, Prod. Faunæ Mediterraneæ, p. 299.

Additional localities.—Off North Coast of Scotland; off Coasts of Durham and North Yorkshire; dredged in Birturbuy, Clifden, and Westport Bays, and Mulroy Lough, Ireland (G. S. B. and D. R.); Isle of Cumbrae; Plymouth; Killary Bay, and deep water off Valentia, Ireland (A. M. N.).

Distribution.—Lervig Bay, Norway, 10–25 fath. (A. M. N.); Bay of Biscay; Crete, Captain Spratt (G. S. B.).

Fossil.—Scotland (Loch Gilp).

50. *Cythere emaciata*, Brady.

1868. *Cythere emaciata*, Brady, Mon. rec. Brit. Ostrac., p. 414, pl. xxx., figs. 31–37.

1874. *Cythere emaciata*, Brady, Crosskey, and Robertson, Post-tert. Entom., p. 161, pl. ix., figs. 14–17.

1885. *Cythere emaciata*, Carus, Prod. Faunæ Mediterraneæ, p. 299.

Additional localities.—At Lamlash, and off North Coast of Scotland; off Durham and North Yorkshire; in the Ouse at Lynn; off Ilfracombe; Eddystone, and

among the Scilly Islands. Dredged in Birturbuy, Clifden, and Westport Bays, and Mulroy Lough, Ireland (G. S. B. and D. R.); Plymouth; Valentia Harbour, Ireland (A. M. N.).

Distribution.—Messina (Seguenza); Naples (A. M. N.); Fosse de Cap Breton, 135 fathoms, Marquis de Folin (G. S. B.).

Fossil.—Scotland (Oban), Ireland (Portrush), Calabria, Sicily.

51. *Cythere runcinata*, Baird.

(Plate xv., figs. 24, 25, 30, 31.)

1850. *Cythere runcinata*, Baird, On several new species of Entomostraca (Proc. Zool. Soc. Lond., part xviii., Annulosa), p. 254, pl. xviii., figs. 7–9.
1850. (?) *Cythere prava*, idem, ibidem, pl. xvii, figs. 13–15.
1868. *Cythere stimpsoni*, Brady, Ann. and Mag. Nat. Hist., ser. iv., vol. iii., p. 48, pl. vii., figs. 9–12.
1880. *Cythere stimpsoni*, Brady, Report Ostracoda "Challenger" Exped., p. 85, pl. xxi., figs. 6 *a–h*.
1885. *Cythere stimpsoni*, Carus, Prod. Faunæ Mediterraneæ, p. 297.
(Not *Cythere stimpsoni*, Brady, Les Fonds de la Mer., vol. i., p. 78, pl. x., figs. 7–10.)

Male. Shell seen from the side elongated, subquadrangular, greatest height situated near the front and equal to rather less than half the length; anterior extremity boldly rounded, fringed with a series of short, sharp teeth, which are largest below the middle; posterior extremity narrower, obliquely truncated above the middle, and armed with four or five teeth below; dorsal margin sloping from before backwards, sinuated in front, and sharply emarginated at the posterior extremity; ventral slightly sinuated in the middle. Seen from above, the outline is elongated and somewhat boat-shaped, nearly thrice as long as broad, and about equal in width throughout; sides nearly parallel, and converging abruptly towards the extremities, which are truncated and formed by the greatly-thickened margins of the valves. The shell-surface is coarsely reticulated, and the sides of the valves are marked by three sharply-cut longitudinal ribs; a similar curved rib running just within the anterior margin and being continued for a short distance along the ventral surface. The shell of the *female* differs in being shorter and stouter, the height greater in proportion to the length. Length of the *male*, ·98 mm.; of the *female*, ·87 mm.

This species is closely allied to *Cythere emaciata*, Brady, and though Dr. Baird's types have not been preserved, or, at any rate, are not accessible, there seems little reason to doubt that the specimens described and figured by him under the specific names *runcinata* and *prava*, belong to the two sexes of a single species—probably to the Mediterranean form, which we have been accustomed to call

C. stimpsoni, but which does not really belong to the species (an Oriental one) originally described by Dr. Brady under that name. Dr. Baird's specimens were from Tenedos, from which place we possess specimens, as well as from various other localities in the Mediterranean.

Habitat.—Dredged in Dartmouth Harbour and Plymouth Sound (A. M. N.), which are at present the only known British localities.

Distribution.—Vigo Bay, dredged by "Challenger" Expedition (G. S. B.); Fosse de Cap Breton, 135 fathoms (G. S. B.), and some locality 30–200 fathoms (A. M. N.); "Valorous" Expedition, Stat. 13, lat. 64° 5′ N., long. 34° 42′ W., 690 fathoms (A. M. N.). In the Mediterranean it occurs commonly, especially in the Levant and Grecian Archipelago (G. S. B.).

52. *Cythere tuberculata* (G. O. Sars).

(Synonym—*C. mutabilis*, Brady.)

1865. *Cythere clathrata*, var. *lyrata*, and (?) var. *latimarginata*, Brady, Trans. Zool. Soc., vol. v., p. 377, pl. lix., figs. 12, 13.

1868. *Cythere tuberculata*, Brady, Mon. rec. Brit. Ostrac., p. 406, pl. xxx., figs. 25–41.

1874. *Cythere tuberculata*, Brady, Crosskey, and Robertson, Mon. Post-tert. Entom., p. 164, pl. v., figs. 7–12.

1885. *Cythere tuberculata*, Carus, Prod. Faunæ Mediterranæ, p. 296.

Generally distributed round the British Islands, in depths of 4 to 40 fathoms; also in Northern Europe, and extending southwards to the Mediterranean.

Distribution.—Widely distributed in 6–40 fathoms, Norway (G.O. Sars). Lervig; Bergen; and Dröbak, Norway (A. M. N.); Holsteinborg Harbour, Greenland, 10 fath., and Lievely Harbour, 5–10 fath., "Valorous," 1875 (A. M. N.); Iceland; Hammerfest Harbour; Spitzbergen; Gulf of St. Lawrence; Hunde Islands, in Baffin's Bay, 60–70 fath. off Bache Island, about lat. 78° N., Capt. Feilden in Nares' Arctic Voyage; West Indies (G. S. B.); Fosse de Cap Breton, Bay of Biscay, 180–200 fath. (A. M. N.); Messina, Sicily (Seguenza).

Fossil.—Scotland, England, Wales, Ireland.

53. *Cythere bradii*, De Folin.

(Plate xvi., figs. 3, 4.)

1869. *Cythere bradii*, De Folin, Les Fonds de la Mer, vol. i., p. 148, pl. xiv., figs. 21–24.

Shell tumid, viewed laterally subrhomboidal, higher in front than behind, height much more than half the length; anterior extremity widely arched; dorsal

margin deeply excavated behind the eye, then convex, and behind suddenly sloping; ventral margin gently flexuous. Seen from above, subhexagonal, the extremities widely mucronate, and the sides very convex; greatest breadth central, subequal to the height. Surface of valves adorned with three very prominent flexuous ribs. Length, ·7 mm.

Habitat.—Bay of Biscay (Marquis de Folin).

54. *Cythere concinna*, Rupert Jones.

(Synonym.—*Cythereis clavata*, G. O. Sars.)

1865. *Cythere concinna*, Brady, Mon. rec. Brit. Entom., p. 408, pl. xxvi., figs. 28–33; pl. xxxviii., fig. 7.

1874. *Cythere concinna*, Brady, Crosskey, and Robertson, Mon. Post-tert. Entom., p. 160, pl. iv., figs. 1–20.

Additional localities.—Dredged in Loch Long and Loch Fyne, off Rothesay, and Roseneath, in the Firth of Clyde; in the Firth of Forth, off coasts of Durham, and North Yorkshire (G. S. B. and D. R.); Unst Haaf, and St. Magnus' Bay, Shetland, 50–60 fath.; Portree Bay, Isle of Skye; off Valentia, Ireland (A. M. N.); Irish Channel, 13–18 fath.; Belfast Lough, 4–10 fath.; Rockport and Brown's Bay, N.E. Ireland; tide-marks (Malcomson).

Distribution.—Cape Frazer, 80 fath., Nares' Arctic Exped., Captain Feilden; Spitzbergen; Iceland; Hammerfest Harbour (G. S. B.); Christiania Fiord, 6–20 fath., and Lofoten Islands, Norway (G. O. Sars); Dröbak, 30–100 fath., and Stoksund, 126 fath., Norway (A.M.N.); Davis Strait, lat. 67° 17′ N., long. 62° 21′ W., six feet below low-water mark (G. S. B. and D. R.).

Fossil.—England (Bridlington), Scotland, Ireland, Norway, and Canada.

55. *Cythere dubia*, Brady.

1868. *Cythere dubia*, Brady, Mon. rec. Brit. Ostrac., p. 409, pl. xxxii., figs. 75, 76.

The only specimens known were found in sand dredged from the Unst Haaf, Shetland, in 1863, where it was dredged again, in 100 fath., in 1867 (A. M. N.).

56. *Cythere emarginata* (G. O. Sars).

(Plate XVI., figs. 1, 2.)

1868. *Cythere emarginata*, Brady, Mon. rec. Brit. Ostrac., p. 166.
1874. *Cythere emarginata*, Brady, Crosskey, and Robertson, Mon. Post-tert. Entom., p. 166, pl. v., figs. 1–6.

The specimen described in the monograph was found by Mr. Robertson off Shetland, where it has since been twice met with by Dr. Norman, on the Unst Haaf and in St. Magnus' Bay.

Distribution.—Lofoten Islands, 6–12 fath., and Öxfiord, Finmark (G.O. Sars); Lervig Bay, Stordoen, 3–25 fath., and off Lervig, 50–100 fath.; Stoksund, 80–100 fath.; Haakelsund, Kors Fiord 3–10 fath., all in Norway (A. M. N.); Spitzbergen, Mr. Lamont (G. S. B.); Godhavn and Holstenbourg Harbour, 5–25 fath., and Davis Strait, lat. 69° 31′ N., long. 56° 1′ W., 100 fath., "Valorous" Exped. (A. M. N.); Hammerfest Harbour; Davis Strait, lat. 67° 17′ N., long. 62° 21′ W. (G. S. B. and D. R.); Iceland (G. S. B.); Franklin Pierce Bay, 13 fath., Nares' Arctic Expedition (Captain Feilden).

Fossil.—England, Scotland, Ireland, Norway, and Canada.

An Arctic species, which is more common as we proceed northwards, and appears to have been abundant in the Glacial epoch.

57. *Cythere finmarchica* (G. O. Sars).

1868. *Cythere finmarchica*, Brady, Mon. rec. Brit. Ostrac., p. 410, pl. xxxi., figs. 9–13.
1874. *Cythere finmarchica*, Brady, Crosskey, and Robertson, Post-tert. Entom., p. 153; pl. x., figs. 18–21.

Additional localities.—Dredged off North coast of Scotland; off coasts of Durham and North Yorkshire; in the river Ouse, Norfolk; off Ilfracombe, and the Eddystone Lighthouse; Fowey Harbour (G. S. B. and D. R.); Shetland; the Minch; Herm, tide-marks (A. M. N.); Irish Channel and Belfast Lough (Malcomson).

Distribution.—Öxfiord, Finmark (G. O. Sars); Haakelsund in Kors Fiord, Norway, 3–10 fath.; Holsteinborg Harbour, Greenland, 10 fath., and Davis Strait (lat. 69° 31′ N., long. 56° 1′ W.), in 100 fath., "Valorous" Exped. (A.M.N.); Bay of Biscay; St. Vincent, Cape Verd (G. S. B.).

Fossil.—Scotland, Norway.

58. *Cythere costata*, Brady.

(Plate XVI., figs. 7, 8.)

1866. *Cythere costata*, Brady, Trans. Zool. Soc., vol. v., p. 375, pl. lx., figs. 5 *a–f*.
1868. *Cythere costata*, Norman, Brit. Assoc. Report, 1868, p. 290.
1874. *Cythere costata*, Brady, Crosskey, and Robertson, Post-tert. Entom., p. 166, pl. v., figs. 21–24.

Female. Carapace compressed, oblong, seen from the side subquadrangular, highest in front of the middle, greatest height equal to somewhat more than half the length; anterior extremity broad and well-rounded; posterior narrow, obliquely truncated, slightly produced below the middle, inferior angle rounded and divided into four or five short obtuse teeth; dorsal margin sloping from the front backwards in a somewhat sinuous line; ventral straight or very slightly sinuated. Seen from above, compressed, irregularly ovate, greatest width situated behind the middle, and equal to rather more than one-third of the length, sides irregularly sinuated and converging gradually to the extremities, which are equal and obtusely pointed. The surface is pitted with closely-set large angular excavations, and each valve has three or four obliquely transverse sharply-cut ribs, which rise from a single longitudinal ridge just within the ventral border and is continued round the anterior margin. Length, 1·1 mm. The shell of the *male* is longer, narrower, and distinctly quadrangular; its greatest height is less than half the length, and the superior margin of the left valve is raised into a conspicuous prominence over the anterior hinge.

Habitat.—Dredged on the Unst Haaf, Shetland (A. M. N.).

Distribution.—The type specimens were dredged by Dr. Sutherland in a depth of 60–70 fath., off the Hunde Islands, Baffin's Bay (G. S. B.); Holsteinborg Harbour, Greenland, 10 fath., living, one ♂ and one ♀, "Valorous" Expedition (A. M. N.); Gulf of St. Lawrence; Franklin Pierce Bay, 13–15 fathoms, and Smith Sound, 78° 37′ N., Captain Feilden in Nares' Arctic Expedition (G. S. B.).

Fossil.—England (Bridlington and Hopton Cliff), Scotland (Paisley).

The species is very similar to *C. emarginata*, but differs in the surface ornament, in the presence of the teeth at the posterior margin, and in the general outline as seen from above and below.

59. *Cythere angulata* (G. O. Sars).

1865. *Cythere clathrata*, var. *nuda*, Brady, Trans. Zool. Soc., vol. v., p. 377, pl. lix., figs. 9, 10.
1868. *Cythere angulata*, Brady, Mon. rec. Brit. Ostrac., p. 409, pl. xxvi., figs. 39–42.
1874. *Cythere angulata*, Brady, Crosskey, and Robertson, Post-tert. Entom., p. 162, pl. iv., figs. 21–24; pl. x., fig. 22.

Additional localities.—Off the north coast of Scotland; Stromness and Firth of Forth; Loch Ryan, and several places in the Firth of Clyde; on the Northumberland, Durham, and Yorkshire coasts; off Scarborough; Dublin, Westport, Clifden, and Birturbuy Bays, and Mulroy Lough, Ireland (G. S. B. and D. R.); off Tarbert, Loch Fyne (A. M. N.); off the Maidens Lighthouse, Irish Channel, 60 fath.; Belfast Lough, 6–8 fath.; between tide-marks, Rockport, Donaghadee, and other places in N.E. Ireland (Malcomson).

Distribution.—Christiania Fiord; Öxfiord, Finmark (G. O. Sars); Haakelsund, Kors Fiord, 3–10 fath.; Lervig Bay, 3–25 fath; Lungegaards-vandet, Bergen; Hollingspollen near Dröbak, 3–10 fath., Norway; Holsteinborg Harbour, Greenland, 10 fath.; Davis Strait, lat. 69° 31′ N. long. 56° 1′ W., 100 fath., "Valorous" Exped. (A. M. N.); Iceland; Hammerfest Harbour; Davis' Strait, lat. 67° 17′ N., long. 62° 21 W., six feet below low-water mark (G. S. B. and D. R.).

Fossil.—England (Bridlington), Scotland, Ireland (Portrush), Norway.

60. *Cythere mucronata* (G. O. Sars).

(Synonym.—*C. spinosissima*, Brady.)

1868. *Cythere mucronata*, Brady, Mon. rec. Brit. Ostrac., p. 415, pl. xxvi., figs. 34–34*a*.
1878. *Cythere mucronata*, Brady, Mon. rec. Brit. Ostrac. Antwerp Crag., Trans. Zool. Soc., vol. x., p. 395, pl. lxvii., figs. 3 *a–d*.

At the time of the publication of the monograph only a single valve of this fine species had been found in sand dredged on the Unst Haaf, Shetland; two additional valves have since been procured from the same locality (A. M. N.).

Distribution.—Hammerfest Harbour (G. S. B.); Lofoten Islands, 300 fath. (G. O. Sars); Stoksund, near the mouth of the Hardanger Fiord, Norway, 126 fath. (A. M. N.) The types of Brady's "*C. spinosissima*" were from M'Andrew and Barrett's dredgings from Norway.

Fossil.—Belgium (Antwerp).

61. *Cythere canadensis*, Brady.

(Plate xv., figs. 14, 15.)

1870. *Cythere canadensis*, Brady, Ann. and Mag. Nat. Hist., ser. iv., vol. vi., p. 452; pl. xix., figs. 4–6.

Shell seen from the side, elongated quadrate, slightly higher in front than behind; height equal to about half the length; anterior extremity obliquely rounded, posterior rectangularly truncated and showing one or two minute nodular projections; dorsal margin gently sloping from the front, but prominent over the anterior hinge; ventral sinuated in the middle and curved upwards behind. Seen from above, the outline is club-shaped, with subparallel sinuous sides, but widest towards the posterior extremity; extremities broad and unevenly truncated; posterior much the wider of the two. Shell-surface uneven, covered with small rounded excavations, showing a slight transverse depression in the middle and another behind, and bordered in front by a wide protuberant flange. Length, ·66 mm.

This species approaches very closely *C. latimarginata*, Speyer, but differs from it in having a less developed marginal band and a less angular outline when viewed from above. The forms referred to by Dr. Brady (*loc. cit.*) as showing a ridged surface ornament belong certainly to other species.

Distribution.—The type specimens were found in dredgings made by Mr. G. M. Dawson in the Gulf of St. Lawrence (G. S. B.); and a few examples have been noticed in dredged material got by the "Valorous" in Davis Strait, lat. 66° 55′ N., long. 55° 30′ W., 57 fathoms (A. M. N.).

62. *Cythere dawsoni*, Brady.

(Plate xvi., figs. 19, 20.)

1870. *Cythere dawsoni*, Brady, Recent Ostracoda of the Gulf of St. Lawrence, Ann. and Mag. Nat. Hist., ser. iv., vol. vi., p. 453, pl. xix., figs. 8–10.

1871. *Cythere dawsoni*, Brady and Crosskey, Fossil Ostracoda Post-tert of Canada and New England, Geological Magazine, pl. ii., figs. 5–7.

1878. (?) *Cythere dawsoni*, Brady, Ostracoda Antwerp Crag, p. 393, pl. xlvi., figs. 3 *a–b*.

Shell viewed laterally quadrangular, highest in front, greatest height equal to half the length; anterior extremity obliquely rounded, bordered with strong blunt teeth; posterior narrower, rectangularly truncate, slightly rounded; dorsal margin

nearly straight, gently sloping backwards, irregularly emarginate; ventral almost straight. Seen from above, subhexagonal; sides nearly parallel, suddenly tapering towards the extremities, which are obtusely mucronate; outline throughout very rugged. Surface of valves marked by irregularly rounded, scattered tubercles and by two irregular longitudinal rows of transversely elongated tubercular eminences. Length, ·75 mm.

Distribution.—Gulf of St. Lawrence, dredged by Mr. G. M. Dawson (G. S. B.).

Fossil.—Montreal and Portland, N. America.

63. *Cythere audax*,* n. sp.

(Pl. xvii., figs. 14, 15.)

Shell, seen from the side, subovate, greatest height anterior, subequal to half the length; anterior extremity very broadly rounded; posterior much narrower, also well rounded; dorsal margin nearly straight, slightly and gradually declining backwards from the front; ventral margin overhung centrally by the protuberance of the shell, the marginal spines of which are seen here protruding. Valves much depressed in front, and here furnished with a marginal fillet, then suddenly swelling into a large protuberance, which occupies the greater part of the shell, and suddenly forms a declivity to the posterior margin, while, as already stated, it overhangs the ventral; round all the margins situated just within them but projecting beyond is a series of blunt flattened spines, which sometimes show a tendency to become bifid at the tip; these spines are easily abraded, and no one specimen has them all perfect; along the ventral edge of the protuberance runs a similar series of large size, and within this again, and parallel to it, passes another row of spines, the hinder ones of this series being often long and acute; over the remaining parts of the surface there are small scattered spinules. Seen from above, the tumidity is very great, the chief expansion behind the middle, and the upper lateral row of spines is seen surmounting this tumidity; at the posterior extremity the sides suddenly but roundly converge, the extremity itself being mucronate; towards the front the narrowing of the valves is more gradual, and the extremity acuminate. Anterior and posterior teeth of the hinge well developed. Length, 1·2 mm.

Dredged by the "Valorous," in 1875, Stat. 12, lat. 56° 11′, N. long. 37° 41 W., in the North Atlantic, in 1450 fath. among Globigerina ooze (A. M. N.).

* *Audax* "Valorous," the name of H. M. Steamship by which the species was dredged.

64. *Cythere mirabilis*, Brady.

1868. *Cythere mirabilis*, Brady, Mon. rec. Brit. Ostrac., p. 415, pl. xxix., fig. 7, 8.
1874. *Cythere mirabilis*, Brady, Crosskey, and Robertson, Mon. Post-tert. Entom., p. 167, pl. viii., figs. 22–26; pl. xv., figs. 13–16.

One valve only was recorded as British in the "Monograph." This was found in Admiralty soundings, taken off Lumpan Head, Lewis (G. S. B.). It has not since been met with in our seas.

Distribution.—Ginevra Bay, Spitzbergen, Mr. Lamont's dredgings (G. S. B.).

Fossil.—By no means rare in the post-tertiary deposits of Scotland; England (Bridlington).

65. *Cythere dunelmensis* (Norman).

(Synonym.—*C. horrida*, G. O. Sars.)

1868. *Cythere dunelmensis*, Brady, Mon. rec. Brit. Ostrac., p. 416, pl. xxx., figs. 1–12.
1874. *Cythere dunelmensis*, Brady, Crosskey, and Robertson, Mon. Post-tert. Entom., p. 168, pl. v., figs. 13–20; pl. xi., figs. 36, 37.

Additional localities.—Dredged off the north of Scotland; Kilchattan Bay, Bute; Firth of Forth, and coasts of Durham and North Yorkshire; Loch Long, Roseneath and Rothesay Bays, Firth of Clyde (G. S. B. and D. R.); Haaf, Shetland; off Valentia, Ireland (A. M. N.); Rockport, Co. Down (Malcomson).

Distribution.—Christiania Fiord, 6–20 faths., and Lofoten Islands, Norway (G. O. Sars); Stoksund, near the mouth of the Hardanger Fiord Norway, 126 faths. (A. M. N.); Iceland; Baffin's Bay; Deevie Bay, Spitzbergen, Mr. Lamont's dredgings (G. S. B.).

Fossil.—England (Bridlington); Scotland, common; Ireland (Belfast and Woodburn).

66. *Cythere antiquata* (Baird).

1868. *Cythere antiquata*, Brady, Mon. rec. Brit. Ostrac., p. 417, pl. xxx., figs. 17–20.
1874. *Cythere antiquata*, Brady, Crosskey, and Robertson, Post-tert. Entom., p. 170, pl. xii., figs. 8–10.
1885. *Cythere antiquata*, Carus Prod. Faunæ Mediterraneæ, p. 301.

Additional localities.—Dredged in the Firth of Forth; Loch Ryan, and several places in the Firth of Clyde; Breydon Water, Norfolk; Rivers Bure and Thames; and

off Eddystone Lighthouse, and Scilly Islands; the Mumbles, near Dublin, Birturbuy and Westport Bays, Ireland (G. S. B. and D. R.); Dartmouth Harbour; off Valentia, Ireland (A. M. N.); Irish Sea, 15–60 faths.; Belfast Lough; Rockport, Co. Down; Island Magee, N. E. Ireland (Malcomson).

Distribution.—Messina (Seguenza); Naples (A. M. N.); Eastern Mediterranean; Piræus, Tenedos, Besika Bay, Constantinople, Jaffa (G. S. B.); Fosse de Cap Breton, Bay of Biscay, 30–60 fath. (A. M. N.).

Fossil.—Scotland (Oban), Ireland (Belfast New Docks), Calabria, Sicily.

67. *Cythere whitei* (Baird).

1868. *Cythere whitei*, Brady, Mon. rec. Brit. Ostrac., p. 416, pl. xxx., figs. 21–24.
1874. *Cythere whitei*, Brady, Crosskey, and Robertson, Post-tert. Entom., p.169, pl. xii., figs. 1–3.
1885. *Cythere whitei*, Carus, Prod. Faunæ Mediterraneæ, p. 301.

Additional localities.—Dublin Bay; Kilchattan Bay, Bute; Girdler Sand, estuary of Thames (G. S. B. and D. R.); Unst Haaf, Shetland; Dartmouth Harbour (A. M. N.); Island Magee, N. E. Ireland, tide-marks (Malcomson).

Distribution.—Eastern Mediterranean at Jaffa; Syria; Gulf of St. Lawrence (G. S. B.); Naples (A. M. N.).

Fossil.—Belfast (New Docks).

68. *Cythere jonesii* (Baird).

Synonyms: *Cythereis fimbriata*, Norman; *Cythere ceratoptera*, Bosquet; *Cythere spectabilis*, G. O. Sars; *C. subcoronata*, Brady (*vix* Speyer); *Cythereis cornuta*, Jones (*junior*).

1868. *Cythere jonesii*, Brady, Mon. rec. Brit. Ostrac., p. 418, pl. xxx., figs. 13–16.
1874. *Cythere jonesii*, Brady, Crosskey, and Robertson, Mon. Post-tert., Entom., p. 171, pl. xii., figs. 4–7.
1878. *Cythere jonesii*, Brady, Ostrac. Antwerp Crag, Trans. Zool. Soc., vol. x., p. 395; pl. lxvii., figs. 2 *a–d*.
1885. *Cythere subcoronata*, Carus, Prod. Faunæ. Mediterraneæ, p. 301.

Additional localities.—Dredged off north coast of Scotland; many places in the Firth of Clyde; off the Durham coast; Birturbuy Bay, and Mulroy Lough, Ireland; and off the Eddystone Lighthouse (G. S. B. and D. R.); off Tarbert, 25 fath., and Skipness, 41 fath. in Loch Fyne; Killary Bay, and off Valentia, 112 fath., Ireland (A. M. N.).

Distribution.—Christiania Fiord (G. O. Sars); off Sartoro, in Bergen Fiord, 15 fath.; and Solems Fiord, Floro, 50–60 fath., Norway, only a single valve in each locality (A. M. N.); Ginevra Bay, Spitzbergen, Mr. Lamont's dredgings; Bay of Biscay; Besika Bay, 14 fath.; Levant; the var. *ceratoptera*, Fosse de Cap. Breton, 35 fath., Marquis de Folin (G. S. B.); Messina (Seguenza).

Fossil.—Ireland (Post-tertiary) var. *ceratoptera*, England, Suffolk (Pliocene), Belgium and France (Eocene).

Genus III.—Limnicythere, Brady.

Acanthopus, Vernet.

[Type, *L. inopinata* (Baird).]

1. *Limnicythere inopinata* (Baird).

(Plate xvii., figs. 18, 19; var. *compressa.*)

1868. *Limnicythere inopinata*, Brady, Mon. rec. Brit. Ostrac., p. 419, pl. xxix., figs. 15–18.
1874. *Limnicythere inopinata*, Brady, Crosskey, and Robertson, Mon. Post-tert. Entom., p. 173, pl. x., figs. 8–11; pl. xxxviii., fig. 9; pl. xxxix., fig. 1.

Generally distributed in ditches, lakes, and slowly running streams throughout the British Islands; found also not uncommonly in estuarine localities, and sometimes dredged at sea, though in these cases it has probably been washed down out of fresh water. We figure a very remarkable form, var. *compressa*, in which the extremities of the shell are produced, and flattened to an extraordinary degree; it was taken in Whitefield Loch, Wigtonshire (A. M. N.).

Distribution.—Sweden (Lilljeborg in Coll. A. M. N.); rivers Scheldt and Maas (G. S. B.).

Fossil.—Scotland, England.

2. *Limnicythere relicta*, Lilljeborg.

(Plate xvii., figs. 8, 9.)

1862. *Cythere relicta*, Lilljeborg, Öfversigt af K. Vet. Akad. Forhand, p. 391, pl. i., figs. 1–17.
1879. *Acanthopus elongatus*, Vernet, Matériaux pour servir a l'étude de la Faune profonde du Lac Léman, p. 516, pl. xxviii., figs. 14–19.
1883. *Limnicythere relicta*, Lilljeborg, Internat. Fisheries Exhib. Lond., Sweden Catalogue, p. 147.

Shell of *female* long-ovate, ventricose, greatest height anterior, height less than half the length; well and broadly rounded at the extremities; dorsal margin

nearly straight, posterior declination the longer; ventral margin deeply sinuated centrally. Seen from above, ovate, with a deep groove on each side where the greatest breadth (had the sides continued evenly there) would have been; extremities mucronate, the anterior the more extended. Valves thin and fragile, greyish-white, everywhere densely hispid; at both extremities, especially the anterior and along the dorsal line, the valves are much compressed, centrally they are gibbously tumid, the tumidity divided above towards the dorsum by a deep transverse depression. On the flattened extremities are seen many (10–12 or more) radiating lines, which when they reach the margin terminate in long setose hairs. Length, ·6 mm.

Shell of the *male* very like that of female, but shorter and more ventricose. The nail of the third pair of feet is very long, almost setiform, and twice as long as the nail of the other feet.

The description and figures are taken from some of Lilljeborg's type specimens in A. M. N.'s collection.

L. relicta has not yet been found in the British Isles. Its habitats, as far as known, are Upsala, Sweden (Lilljeborg), and the Lake of Geneva (Vernet).

3. *Limnicythere sancti-patricii*, Brady and Robertson.

(Plate xvii., figs. 1, 2.)

1869. *Limnicythere sancti-patricii*, Brady and Robertson, Ann. and Mag. Nat. Hist., ser. iv., vol. iii., p. 17, pl. xviii., figs. 8–11; pl. xxi., fig. 4.

1874. *Limnicythere sancti-patricii*, Brady, Crosskey, and Robertson, Mon. Post-tert. Entom., p. 174, pl. ii., figs. 1–3.

Shell, as seen from the side, reniform, higher at the extremities than in the middle, greatest height anterior, equal to half the length; extremities well rounded and entirely destitute of serratures, the anterior slightly the larger; superior margin almost straight; inferior deeply sinuated in the middle. Seen from above, the outline is irregularly rhomboidal, widest somewhat behind the middle; extremities acuminate; greatest width rather less than the height. Seen from the front, the outline is widest at the base, with gradually converging sides and broadly arched apex; ventral border convex and prominently keeled in the middle. Surface of the valves sculptured with closely-set, polygonal excavations, and marked across the middle with a wide and deep sinuous furrow, in front of which is another of similar character but smaller; behind the posterior furrow the shell rises towards the ventral border in a prominent rounded eminence, the summit of which often takes a tubercular form; the ventral surface is furrowed in a longitudinal direction, and also marked more or less with cross striæ. Animal almost exactly like that of

C. inopinata; abdomen slightly hirsute and produced into two lobes, each with a short terminal seta. Length, ·8 mm.

Habitat.—This is a larger and more robust species than *L. inopinata* or *L. relicta;* from the former it differs also in the absence of marginal serratures, and in having usually a less wrinkled and more neatly-sculptured surface. The type specimens were found in Lough Moher, about five miles south of Westport (county Mayo), and more recently we have taken specimens in dykes near Whittlesea; in the Rivers Nene and Cam; and in Bishop's Loch, near Glasgow (G. S. B. and D. R.); Whitefield Loch, Wigtonshire; Lochs Ruter and Aber, Kirkcudbrightshire; Lough Neagh, Ireland (A. M. N.); Loch Fergus, Kirkcudbrightshire (G. S. B.).

Fossil.—England (Branston Fen, Lincolnshire).

The rounded eminence, often assuming a tubercular aspect, which is situated near the ventral margin on the hinder part of the valves, seems to be a constant or nearly constant character by which the species may be distinguished from its congeners. It has, moreover, a peculiar aspect from the lesser central height of the shell, which, while characteristic of the genus, is most strongly marked in this species.

4. *Limnicythere monstrifica* (Norman).

1868. *Limnicythere monstrifica*, Brady, Mon. rec. Brit. Ostrac., p. 420, pl. xxix., figs. 9–12.
1874. *Limnicythere monstrifica*, Brady, Crosskey, and Robertson, Post-tert. Entom., p. 175, pl. ii., figs. 8 *a–d*.

Additional localities.—Dykes at Whittlesea; Breydon Water; Rivers Cam at Ely, and Ouse at Lynn (G. S. B. and D. R.).

Fossil.—England (Branston Fen, Lincolnshire).

Genus IV.—Cytheridea Bosquet.

[Type, *Cytheridea Mülleri* Von Münster.]

1. *Cytheridea elongata*, Brady.

Synonyms: *Cythere angustata*, Baird (*nec Cytherina angustata*, Münster).

1868. *Cytheridea elongata*, Brady, Mon. rec. Brit. Ostrac., p. 421, pl. xxviii., figs. 13–16; pl. xl., fig. 6.
1869. *Cytheridea cornea*, Brady and Robertson, Ann. and Mag. Nat. Hist., ser. iv., vol. iii., p. 18, pl. xx., figs. 9, 10 (*junior*).
1874. *Cytheridea elongata*, Brady, Crosskey, and Robertson, Mon. Post-tert. Entom., p. 181, pl. ix., figs. 10–13.

Of common occurrence round the southern British coasts from low-water mark to depths of 30–40 fath.; occasionally also in estuaries and tidal rivers. It is much scarcer as we proceed northwards.

Distribution.—St. Malo, Bay of Biscay; Rivers Scheldt and Maas, Holland; Iceland; Gulf of St. Lawrence (G. S. B.); Fosse de Cap Breton, 30–60 fath., and Naples (A. M. N.).

Fossil.—Scotland, England, Ireland.

Type specimens in Dr. Norman's collection received by him from Dr. Baird prove conclusively that *C. elongata* is the *C. angustata* of that author.

2. *Cytheridea papillosa*, Bosquet.

Synonyms: *Cythere bradii and debilis*, Norman; *Cyprideis bairdii*, G. O. Sars.

1868. *Cytheridea papillosa*, Brady, Mon. rec. Brit. Ostrac., p. 423, pl. xxviii., figs. 1–6; pl. xl., fig. 1.

1874. *Cytheridea papillosa*, Brady, Crosskey, and Robertson, Mon. Post-tert. Entom., p. 176, pl. vi., figs. 12–15.

1878. *Cytheridea papillosa*, Brady, Ostracoda, Antwerp Crag, p. 396, pl. lxii., figs. 1 *a–d*.

Additional localities.—Rothesay, Roseneath, and Greenock, in the Firth of Clyde; off the coasts of Durham and Yorkshire; Westport Bay, Ireland (G. S. B. and D. R.); Shetland; off Valentia, Ireland (A. M. N.); Irish Channel and Belfast Lough (Malcomson).

Distribution.—Abundant in Christiania Fiord, and as far north as the Lofoten Islands (G. O. Sars); Dröbak, Lervig, Stoksund, Bergen, &c., Norway; Holstenbourg Harbour, and in Davis Strait, lat. 69° 31′ N., long. 51° 1′ W., 100 fath., and lat. 64 5′ N., long. 56° 47′ W., 410 fath.; "Valorous" Expedition (A. M. N.); Hunde Islands, Baffin's Bay, 60–70 fath.; Iceland; Deevie Bay, Spitzbergen, Mr. Lamont; Davis Strait; Gulf of St. Lawrence (G. S. B.).

Fossil.—Tertiary; France and Belgium. Post-tertiary; Scotland, England, Norway, Canada.

3. *Cytheridea punctillata*, Brady.

Synonym: *Cyprideis proxima*, G. O. Sars.

1866. *Cytherideis* (?) *pulchra*, Brady, New and imperfectly known marine Ostracoda, Trans. Zool. Soc., vol. v., p. 368, pl. lviii., figs. 3 *a–c*.

1868. *Cytheridea punctillata*, Brady, Mon. rec. Brit. Ostrac., p. 424, pl. xxvi., figs. 35–38; pl. ix., figs. 9–11.

1874. *Cytheridea punctillata*, Brady, Crosskey, and Robertson, Mon. Post-tert. Entom., p. 177, pl. vi., figs. 1–11.

1885. *Cytheridea punctillata*, Carus, Prod. Faunæ Mediterraneæ, p. 303.

Additional localities.—Dublin Bay; Roseneath and Rothesay, in the Firth of Clyde (G. S. B. and D. R.); Seaton Carew, Co. Durham (G. S. B.); Inverary and off Tarbert and Skipness, in Loch Fyne; off Valentia, Ireland (A. M. N.).

Distribution.—Christiania Fiord, and thence to Finmark (G. O. Sars); Dröbak, Christiania Fiord (A. M. N.); Hunde Islands, Baffin's Bay, 28–40 fath., off Cape Frazer, 80 fath.; Spitzbergen, Mr. Lamont; Iceland; Gulf of St. Lawrence (G. S. B.), lat. 60° 39′ N., long. 3° 9′ W., 203 fath., "Porcupine," 1869 (A. M. N.); Messina (Seguenza).

Fossil.—Scotland, England, Ireland, Sicily.

4. *Cytheridea stigmosa*, n. sp.

(Plate xvi., figs. 21, 22.)

Shell subovate, highest near the front, greatest height rather more than half the length; anterior extremity higher than the posterior, well and evenly rounded; posterior extremity much narrower, well rounded; dorsal margin arcuate throughout, highest in front of the middle; from this point backwards the declination is gradual and even, and the convexity slight, while in front the slope is much more sudden, though the convexity is much greater, the arch here being bold; ventral margin very slightly sinuated in the middle. Seen from above, the outline is ovate, the greatest breadth near the posterior extremity, which is rounded, while forwards the sides gradually and slowly approximate, the anterior extremity being blunt and scarcely acuminate. Surface of valves sculptured everywhere with little circular pittings, which have a tendency to arrange themselves into lines, more especially round the margins; there are also a few scattered, opaque white papillæ, which are conspicuous against the glassy and semi-transparent general structure of the valves. Length, ·3 mm.

Habitat.—Off Valentia, Ireland, 112 fath. (A. M. N.).

5. *Cytheridea similis*, Brady.

(Plate xvii., figs. 26, 27.)

1869. *Cytheridea similis*, Brady, Les Fonds de la Mer. (vol. i., p. 147, pl. xiv., figs. 19, 20.

Shell, as seen from the side, subovate, its greatest height in the centre exceeding half the length; anterior extremity rounded, posterior obtusely rounded; dorsal margin arched; ventral margin nearly straight. Seen from above, ovate, constricted in the middle: behind this constriction is the greatest breadth. Surface of valves finely punctate and furnished with a few small rounded tubercles. Length, ·88 mm.

Habitat.—Bay of Biscay, Marquis de Folin (G. S. B.).

6. *Cytheridea torosa* (Jones).

1868. *Cytheridea torosa*, Brady, Mon. rec. Brit. Ostrac., p. 425, pl. xxviii., figs. 7–12; pl. xxxix., fig. 5.
1868. *Cytheridea littoralis*, Brady, Nat. Hist. Trans. Northum. and Durham, vol. iii., p. 6.
1870. *Cytheridea torosa*, Brady and Robertson, Ann. and Mag. Nat. Hist., ser. IV., vol. vi., p. 21, pl. viii., figs. 6, 7.
1874. *Cytheridea torosa*, Brady, Crosskey, and Robertson, Post-tert. Entom., p. 178, pl. xv., figs. 11, 12, and var. *teres*, pl. vii., figs. 1, 2.
1886. *Cytheridea torosa*, Carus, Prod. Faunæ Mediterraneæ, p. 302.
1888. *Cytheridea torosa*, Dahl, Die Cytheriden der Westlich. Ostsee, p. 16, pl. i., fig. 31, pl. ii., figs. 32–48.

Additional localities.—Type, rivers Ouse, Deben, Stour, Thames, and throughout the broads and dykes of the Fen district; Dungeness Bay; Westport Bay, Ireland (G. S. B. and D. R.); Newport, county Mayo (A. M. N.). Var. *teres*, in the Firth of Clyde; common throughout the Fen district; ditches on Cardiff Moor (G. S. B. and D. R.); Crossens, Lancashire (A. M. N.); Ellesmere Canal, near Ellesmere, Shropshire (G. S. B.).

Distribution.—In an estuary called Engervand, near Christiania (G. O. Sars), Piræus, Besika Bay, Hellespont, Smyrna, Latakié, Beyrout, Jaffa, Port Said, Sea of Azov; rivers Scheldt and Maas, Holland; Gibraltar; Adour Maritime, France (G. S. B.), Western Baltic (Dahl).

Fossil.—Crag: Woolwich and Isle of Wight. Post-tertiary: Scotland, England, South Wales, Ireland.

7. *Cytheridea castanea*, Brady.

(Plate XXI., figs. 3, 4.)

1870. *Cytheridea castanea*, Brady, Les Fonds de la Mer., vol. i., p. 117, pl. xiii., figs. 19–21; and pl. xiv., figs. 1, 2.

Shell seen from the side elongated, subovate, highest near the front, height equal to half the length; anterior extremity rounded, bordered below the middle with six short, blunt teeth; posterior extremity obliquely rounded and somewhat narrowed, bearing at the ventral angle a large, slightly-curved and sharp spine; dorsal margin forming a flattened arch, which is obscurely angulated in front of the middle, curved very gently, except posteriorly, where it slopes steeply. Seen from above, elongate-ovate, much more than twice as long as broad, widest in the middle; subacute in front, moderately broad and well-rounded behind, where it is slightly emarginate in the middle, and uneven, owing to the lesser size of the

right valve. Shell-surface smooth, beset with numerous small rounded papillæ. Colour, reddish brown. Length, 1·3 mm.

Distribution.—Dredged by the Marquis de Folin in the Bay of Biscay (G. S. B.). Port Said, Marquis de Folin (G. S. B.). The figures and decription now given are from Mediterranean specimens. We have had no opportunity of re-examining the Bay of Biscay specimens.

8. *Cytheridea lacustris* (G. O. Sars).

1868. *Cytheridea lacustris*, Brady, Mon. rec. Brit. Ostrac., p. 472, pl. xxvi., figs. 18–21; and pl. xi., fig. 2.

1874. *Cytheridea lacustris*, Brady, Crosskey, and Robertson, Mon. Post-tert. Entom., p. 179, pl. vi., figs. 16–20.

1879. *Acanthopus resistans*, Vernet, Matériaux pour servir à l'étude de la Faune profonde du Lac Léman, p. 509, pl. xxvii., figs. 1–13.

The anatomical details given by Dr. Vernet in his notice of *Acanthopus* are precisely those belonging to the genus *Cytheridea*, and a renewed dissection of two species—*C. lacustris* and *C. papillosa*—since seeing Dr. Vernet's paper, leaves us unable to find any distinctions of generic importance. We have not, however, as yet succeeded in finding the male of *C. lacustris.*

Additional localities.—Loch Lomond; the river Nene at Peterborough, and the Thames Estuary (G. S. B. and D. R.); Canal near Morningside, Edinburgh (D. R.); Lough Neagh, Ireland (A. M. N.).

Distribution.—Norway (G. O. Sars); Lake Mälar, Sweden (Lilljeborg in Coll. A. M. N.).

Fossil.—Scotland, England.

9. *Cytheridea* (?) *subflavescens*, Brady.

1868. *Cytheridea subflavescens*, Brady, Mon. rec. Brit. Ostrac., p. 429, pl. xxxiv., figs. 53–55.

Additional localities.—Near Rothesay, and in Loch Fyne (G. S. B. and D. R.); off Tarbert, in 25 fath., and off Skipness, 40 fath. in Loch Fyne; St. Magnus Bay, Shetland; the Minch, 45–60 fath.; between the Cumbrae Islands, 15–25 fath. (A.M.N.); Irish Channel, dredged; and Belfast Lough (Malcomson).

It is a rare species, and when found is scarce, numerically The characters are very constant, and well-marked.

10. *Cytheridea fascis*, n. sp.

(Plate XVI., figs. 23, 24.)

Shell, as seen from the side, broadly subtriangular, greatest height anterior, equal to two-thirds of the length; anterior extremity very broad, well and evenly rounded; posterior obliquely subtruncate, most produced at the infero-posteal corner, where it is angled, thence the margin sweeps upwards and backwards arcuately, the rise at first sudden, afterwards gradual, until the highest point of the dorsal margin is attained in front of the middle, and from this point the forward and downward sweep of the dorsal margin is well rounded and rapid to the anterior extremity; ventral margin (of the lateral edge of the shell, which assumes the aspect of the ventral margin when seen from the side) very slightly convex throughout the greater part of the length, until a small shallow sinus is reached, which is situated just before the hinder extremity. Valves flat or rather hollowed everywhere, except at the edges and where a rounded boss rises in the centre; surface uneven; anterior margin furnished with 6–7 teeth, which curve forwards. Colour glassy, semi-opaque, with scattered opaque white tubuli passing through the shell to the surface. Notwithstanding the flattened surface of the valves, the shell is extraordinarily thick, the sides rising perpendicularly from the margin, and ultimately, at least in front, furnished at their summit with an overhanging edge; the thickness is excesssive at the extremities, and especially behind. Seen from above, the outline is like that of a sheaf tied in the centre, with a knot appearing on each side; in front of and behind this knot is a constriction, and then the sides diverge in both directions to broad truncate extremities, the hinder of which is, at its termination, equal to half the length and two-thirds the height of the shell; while the somewhat narrower, though still very broad front extremity, has three rib-like projections, a central formed by the junction of the valves, and on each outer edge a lateral formed by the projected ledge of the upper lateral margin of the valves, while broad rounded furrows occupy the interspaces of the riblets; the outer riblets are continued backwards, slightly converging, until near the centre of the length of the dorsum they become effaced. The end view is in form a narrow round-topped arch, with a bulbous projection in the outer side of the middle of the lateral walls, base flat. Seen from below, the form is a long oblong, with nearly parallel sides, but rather narrower in front, both extremities broadly and abruptly truncate, a nodulous swelling near the middle on each side. Length, ·8 mm.

Distribution.—This remarkable species was dredged by H. M. S. "Valorous," in Davis Strait, Stat. 6., lat. 64° 5′ N., long. 56° 47′ W., in 410 fath. (A. M. N.).

11. *Cytheridea sorbyana*, Jones.

Synonyms: *Cytheridea dentata* and *inermis*, G. O. Sars.

1868. *Cytheridea sorbyana*, Brady, Mon. rec. Brit. Ostrac., p. 428, pl. xxix., figs. 1–6.
1874. *Cytheridea sorbyana*, Brady, Crosskey, and Robertson, Mon. Post-tert. Entom., p. 180, pl. vii., figs. 7–12.

Additional localities.—80–100 fath., 20–25 miles N.N.W. from Burrafirth Lighthouse, Shetland; the Minch; and 112 fath. off Valentia, Ireland (A. M. N.).

Distribution.—Stoksund, in Hardanger Fiord, Norway, in 80–100 fath. (A.M.N.); Öxfiord, Finmark (G. O. Sars); Deevie Bay, Spitzbergen, Mr. Lamont, and off Cape Frazer, 80 fath., Capt. Feilden in Nares' Arctic Expedition (G. S. B.).

Fossil.—Crag: England. Post-tertiary: England, Scotland, Norway, Canada.

Cytheridea inæqualis, Brady and Robertson.

[The species, described by us under this name in "The Annals and Magazine of Natural History" for 1870, was taken by the dredge in the river Cam, at Ely. The probability is that the shell was a fossil one; and on this account we prefer, for the present, to withdraw it from the list of recent species.]

Genus V.—EUCYTHERE, Brady.

= *Cytheropsis*, G. O. Sars.

[Type, *Eucythere declivis* (Norman).]

Eucythere declivis (Norman).

Synonym.—*Cytheropsis tenuitesta*, G. O. Sars.

1868. *Eucythere declivis*, Brady, Mon. rec. Brit. Ostrac., p. 430, pl. xxvii., figs. 22–26, and 52–55.
1868. *Eucythere argus* (G. O. Sars), idem, ibidem, p. 431, pl. xxvii., figs. 49-51 (variety).
1868. *Eucythere anglica*, idem, ibidem, p. 475, pl. xxv., figs. 49, 50 (variety).
1869. *Eucythere declivis*, var. *prava*, Brady and Robertson, Ann. and Mag. Nat. Hist., ser. IV., vol. iii., p. 18., pl. xxi., figs. 12–14.
1874. *Eucythere anglica*, Brady, Crosskey, and Robertson, Mon. Post-tert. Entom., p. 183, pl. x., figs. 12–15 (variety).

On a careful re-examination of a large series of specimens belonging to this genus, we are disposed to think that all ought to be referred to one species. That the extreme forms of the series differ very considerably from each other, both in form and surface-ornament, there can be no doubt; but there exist likewise numberless intermediate forms which it is extremely difficult, or perhaps impossible, to

assign with accuracy if more than one specific form be allowed. We do not see how the two forms described under the specific names *argus* and *anglica* can with propriety be retained as separate species. They are, in all probability, local and depauperized forms of *declivis*. The *declivis* and *argus* forms are very generally distributed round the British Islands, ranging usually between 15 and 40 fath. We have not been fortunate enough in any case to meet with shells containing the animal in a state sufficiently perfect for dissection.

A more remarkable variety than any yet described has been found by A. M. N. on the Shetland Haaf. It is of very large size (·7 mm.), side outline as usual, but gradually increasing in tumidity from behind forwards, until, at a short distance from the anterior extremity, it becomes extremely gibbous above, while the ventral margin below the gibbosity and the anterior extremity itself are depressed; the anterior extremity is much broader in proportion than in specimens of lesser size, and is obliquely rounded; the surface of the gibbous portion is more or less sculptured with a raised reticulation. Viewed dorsally, the breadth in front of the middle is greater than half the length, and the angle formed by the united valves in front is almost a right-angle.

This species is almost ubiquitous in the British seas, ranging usually from about 4 to 40 fathoms.

Distribution.—Christiania Fiord, and thence to the Lofoten Islands and Finmark (G. O. Sars), Christiania, Hardanger, and Oster Fiords, Norway; Fosse de Cap Breton, Bay of Biscay, 180–200 fath.; off Isle of Capri, and at Naples (A. M. N.); Gulf of St. Lawrence (G. S. B.).

Fossil.—Scotland, South Wales, Ireland, Norway, Canada.

Genus VI.—Krithe, Brady, Crosskey, and Robertson.

= *Ilyobates*, G. O. Sars.

[Type, *Krithe bartonensis* (Jones).]

1. *Krithe bartonensis* (Jones).

1856. *Cytherideis bartonensis*, T. R. Jones, Mon. Tert. Entom., p. 50, pl. v., figs. 2 *a–b* and 3 *a–b*.
1865. *Ilyobates prætexta*, G. O. Sars, Oversigt af Norges marine Ostracoder, p. 60.
1868. *Ilyobates bartonensis*, Brady, Mon. rec. Brit. Ostrac., p. 432, pl. xxxiv., figs. 11–14; and pl. xl., fig. 5.
1874. *Krithe bartonensis*, Brady, Crosskey, and Robertson, Mon. Post-tert. Entom., p. 184, pl. ii., figs. 22–26.
1880. *Krithe bartonensis*, Brady, Report "Challenger," Ostracoda, p. 113, pl. xxvii., figs. 2 *a–d*.

Additional localities.—Off North coast of Scotland; Roseneath and Rothesay, in the Firth of Clyde; off the coasts of Durham and North Yorkshire (G. S. B. and

D. R.), Inverary, and off Tarbert, Loch Fyne, 25 fath.; off Valentia, Ireland (A. M. N.).

Distribution.—Christiania Fiord, 6–20 fath., and thence to Lofoten Islands, 40–50 fath. (G. O. Sars), Dröbak, 30–100 fath.; Hardanger Fiord, 210 fath.; Oster Fiord, West Norway, 100–200 fath.; Fosse de Cap Breton, Bay of Biscay, 180–200 fath. (A. M. N.): "Challenger," off the Ki Islands (between Australia and New Guinea), 580 fath., Stat. 191; and off Christmas Harbour, Kerguelen Island, 120 fath., Stat. 149 (G. S. B.).

Fossil.—Scotland, England, Norway, Calabria (Seguenza), var. *monosteracensis.*

This species is extremely variable. In some Norwegian examples the shell is so produced as to be three times as long as the height, and the dorsal margin so evenly and equally arched throughout that there is no posterior truncation, though the infero-posteal angle remains; in other narrow male forms the infero-posteal angle is exserted, and forms a little rostrum; while in some female forms the shell is so much shorter than usual, that the outline closely corresponds with that of *Krithe glacialis*, except that the supero-posteal portion of the shell is not quite so much protruded, and is rounded without angularity.

2. *Krithe producta*, Brady.

(Plate xvii., figs. 5–7.)

1880. *Krithe producta*, Brady, Report "Challenger," Ostracoda, p. 114, pl. xxvii., figs. 1 *a–g*.

Shell of *female* more flexuous and more tumid than that of *Krithe bartonensis.* Seen from the side, subreniform; greatest height situated in the middle, and equal to more than half the length; anterior extremity well and evenly rounded, posterior obliquely subtruncated, rounded off above, and obscurely angulated below, often slightly sinuated above the middle; the margin itself below the middle of the valve is not seen, being incurved and hidden under a projecting lip which ends at the ventral angle; dorsal margin boldly arched, ventral almost straight. Seen from above, ovate, widest in the middle, width equal to quite half the length, pointed in front, wide, truncate, and centrally deeply emarginated behind. Surface of valves quite smooth, or beset with numerous minute, closely-set punctures, and a few distant circular tubercles. The shell of the *male* is much narrower and more elongated. The foregoing description applies to the left valve, the right valve differs considerably in outline, and is narrower behind. Length of female, 1·1 mm.; of male, 1·3 mm.

Distribution.—This is extensive. "Porcupine" Expedition, 1869, Stat. 19, lat.

54° 53′ N., long. 10° 56′ W., 1360 fath.; Stat. 74, lat. 60° 39′ N., long. 3° 9′ W., 203 fath. "Valorous" Exped., 1875, Stat. 12, lat. 56° 11′ N., long. 37° 41′ W., 1450 fath (A. M. N.). The following are the places in which it occurred in the "Challenger" Expedition:—Three in the North Atlantic (Stats. 70, 76, 85), ranging from lat. 28° 42′, to 38° 25′ N., and long. 18° 6′ to 35° 50′ W., in 900 to 1675 fath.; one South Atlantic (Stat. 120), lat. 8° 37′ S., long. 34° 28′ W., 350 fath.; also midway between the Cape of Good Hope and Kerguelen Island; off North Brazil; off Prince Edward's Island, and off Sydney (G. S. B.).

3. *Krithe angusta*, n. sp.

(Plate XVII., figs. 10–13.)

Shell of *female* narrow, oblong; seen from the side, of nearly equal height throughout; anterior margin well and evenly rounded, posterior obliquely rounded, without angularity above or below; dorsal margin straight; ventral sinuated rather in front of the middle; greatest height scarcely more than one-third the length. Seen from above, narrow, cuneiform; greatest width posterior less than one-third of the length; gradually tapering forwards to an acute extremity; posterior extremity rounded (without the characteristic emargination of the genus). Shell of *male* more produced than that of the female, greatly elongated, of nearly equal height throughout, but slightly higher in front; greatest height less than one-third the length; anterior, dorsal, and ventral margins as in female; posterior more oblique, no angle above, but infero-posteal corner produced, the point rounded; the usual lip of the genus only slightly indicated. Seen from above, of the same shape as, but still more compressed than, the female; greatest width equal one-fourth the length; posterior extremity narrowly subtruncate, but not emarginate. Valves transparent, glossy, with a few scattered opaque white specks, and the extremities ornamented with a series of radiating white tubes, which traverse the substance of the shell. Length, ·4 mm.

Although we have not taken these assumed ♂ and ♀ together, nor examined the animals, yet, from analogy, there seems to be every reason to suppose that they represent the two sexes of one species. Numerically, the species is very scarce, and easily overlooked on account of its small size. It has certainly nothing to do with the young of *K. bartonensis*, which are short, high, obese, and remarkably truncate behind.

Habitat.—Female: Oster Fiord, West Norway, 100–375 fath.; off Sartoro, Bergen Fiord, 15–40 fath. *Male:* Dröbak, Christiania Fiord, 100 fath.; Hardanger Fiord, off Stordöen, 210 fath. It has only as yet been found in the Norwegian seas (A. M. N.).

4. *Krithe reniformis* (Brady).

(Plate xxi., figs. 23, 24.)

1868. *Paradoxostoma* (?) *reniforme*, Brady, Contrib. to Study of Entomostraca, Ann. and Mag. Nat. Hist., ser. iv., vol. ii., p. 224, pl. xv., figs. 1, 2.

Shell, seen from the side, elongated, elliptical, of nearly equal height throughout; greatest height at the anterior extremity, and equal to about two-fifths of the length; anterior extremity very broadly and evenly rounded, point of greatest projection central; posterior extremity nearly as broad as the anterior, its upper portion is obliquely cut away, but the extremity itself is rounded, the point of greatest projection being nearly central; dorsal margin perfectly straight in all its central portion, and without arcuation behind; sweeping down obliquely to the extremity, but in front the downward slope is well-arched; ventral margin with a short but rather deep sinuation in front of the middle; both before and behind the sinuation the margin is gently convex. Seen from above, the form is slightly cuneate, the greatest breadth rather less than the height, situated behind the middle; sides converging gradually in front to an acute extremity; behind they are rounded, and meet much more suddenly, so that the extremity is rather blunt. Valves thin, glassy, and pellucid, dotted with opaque white specks. Length, ·50 mm.

The type specimens were found by G. S. B. in sand from Tenedos; it has since been dredged by A. M. N. in 180–200 fathoms, in the Fosse de Cap Breton, Bay of Biscay, and in shallow water at Naples. From an examination of these specimens we find that they belong to the genus *Krithe*.

5. *Krithe glacialis*, Brady, Crosskey and Robertson.

1874. *Krithe glacialis*, Brady, Crosskey, and Robertson, Mon. Post-tert. Entom., p. 184, pl. vi., figs. 21–26.

Shell of *female*, as seen from the side, subrhomboidal, almost equal in height throughout; height equal to half or sometimes nearly two-thirds of the length; anterior extremity evenly rounded, posterior obliquely truncate, angled at junction with dorsal margin, and pointedly angled at junction with ventral margin; dorsal margin gently arched; ventral slightly convex in front, nearly straight behind. Outline, as seen from above, ovate, widest in the middle, acutely pointed behind, rectangularly truncate in front, greatest width slightly exceeding

half the length, posterior extremity slightly emarginate at each side of the median line. End view nearly circular. Shell of the *male* narrower and longer, dorsal margin nearly straight; ventral nearly straight, but slightly convex in front; infero-posteal angle more pronounced, the overhanging lip at the infero-posteal portion of the shell (as usual in the genus) well developed. Shell surface smooth, bearing several scattered circular papillæ "and a few rather short thick hairs." Lucid spots large, oblong, four in a transverse row a little below and in front of the centre of the valve, and two or three a little in advance of the main group.*

Length: female, ·75; male, ·95 mm. These measurements are taken from fossil (Errol) examples. Our recent specimens are somewhat smaller.

Habitat.—"Porcupine" Exped., 1869; Stat. 41, lat. 49° 4′ N., long. 12° 22′ W., 584 fath. (A. M. N.).

Fossil.—Scotland (Errol), Norway.

Genus VII.—Loxoconcha, G. O. Sars.

= *Normania*, Brady.

[Type, *L. impressa*, Baird.]

1. *Loxoconcha impressa* (Baird).

(Plate xxiii., fig. 7.)

Synonyms: *Loxoconcha rhomboidea*, G. O. Sars (nec. *C. rhomboidea*, Fischer); *Cythere carinata*, Brady.

1868. *Loxoconcha impressa*, Brady, Mon. rec. Brit. Ostrac., p. 433, pl. xxv., figs. 34–40; pl. xl., fig. 4.

1875. *Loxoconcha impressa*, Brady, Crosskey, and Robertson, Mon. Post-tert. Entom., p. 185, pl. viii., figs. 1–4.

1888. *Loxoconcha rhomboidea*, Dahl, Die Cytheriden der Westlich. Ostsee, p. 22, pl. ii., figs. 59–67.; pl. iii., figs. 68–71.

This species is so universally distributed in the British seas, that it is needless to add, as might be done very largely, to the already long list of localities given in the "Monograph." It occurs in all sorts of situations, from depths of 60 fath. up to shallow estuaries, and in brackish and even fresh water; as, for instance, in the Belfast Canal, and in the rivers Deben at Woodbridge and Stour at Man-

* This is the usual arrangement of the lucid spots in the genus; sometimes one or more in the transverse row are constricted or divided (in *K. producta*, as figured in "Challenger" Report, three of them are completely divided); sometimes there are in addition one, two, or three scattered lucid spots between the transverse row and the dorsal margin. All the above variations have been noticed in *K. producta*.

ningtree. It seems, however, to be more abundant and more finely developed on the southern and Atlantic than on the north-east coasts.

Distribution.—Coasts of Norway and Finmark, generally distributed (G. O. Sars and A. M. N.); Sweden (Lilljeborg); Germany (Zenker); Fosse de Cap Breton, Bay of Biscay, 30–60 fath.; Naples (A. M. N.); West Baltic (Dahl).

Fossil.—Scotland, Ireland, Norway, Calabria (Seguenza).

2. *Loxoconcha guttata* (Norman).

1865. *Loxoconcha granulata*, G. O. Sars, Oversigt af Norges marine Ostracoder, p. 64.
1868. *Loxoconcha granulata*, Brady, Mon. rec. Brit. Ostrac., p. 434, pl. xxvi., figs. 51, 52.
1868. *Loxoconcha guttata*, idem, ibidem, p. 436, pl. xxvii., figs. 40–44.
1869. *Loxoconcha granulata*, idem, Nat. Hist. Trans. North. and Durham, vol. iii., p. 368, pl. xiii., figs. 5–7.
1874. *Loxoconcha guttata*, Brady, Crosskey, and Robertson, Mon. Post-tert. Entom., p. 186, pl. viii., figs. 5–7.
1880. *Loxoconcha guttata*, Brady, Report "Challenger," Ostracoda, p. 120, pl. xxix., figs. 1 *a–f*.
1885. *Loxoconcha guttata*, Carus, Prod. Faunæ Mediterraneæ, p. 305.

L. guttata (Norman) was described from full-grown examples of the species of which *L. granulata* is the condition in middle age. Young specimens are more elongated in proportion to their height; the surface is finely punctate, the edge of the valves acute; the shell, seen dorsally, has acute extremities. With increasing age the punctations pass by degrees through smaller foveolæ, until they become the cells of the adult; the margin of the valves also becomes more thickened, ultimately appearing as a fillet, and the consequence of this is in full-grown specimens to produce the aspect, when viewed from above, which is illustrated in fig. 41 of the "Monograph."

Additional localities.—Off the North of Scotland; Firth of Forth; Clyde district generally; off Dungeness Bay, and off Eddystone Lighthouse; North Yorkshire; in the river Bure, Norfolk; off Penarth Head; Ilfracombe; the Scilly Isles; Dublin, Clifden, Birturbuy, and Westport Bays, and Loughs Swilly and Mulroy, Ireland (G. S. B. and D. R.); Inverary, and off Skipness in Loch Fyne; the Minch; off Berry Head, in Start Bay, and Dartmouth Harbour, Devon; Killary Bay, Co. Galway, and in Valentia Harbour, Ireland (A. M. N.); Irish Channel and Belfast Lough (Malcomson).

Distribution.—Christiania Fiord, Norway, 10–12 fath. (G. O. Sars); Lervig Bay, Stordöen, Norway; Fosse de Cap Breton, Bay of Biscay, 30–200 fath.; off Isle of Capri, Mediterranean (A. M. N.); Vigo Bay, Spain, "Challenger;" and Port Said (G. S. B.).

Fossil.—Scotland (Drip Bridge), Sicily.

3. *Loxoconcha viridis* (Müller).

1785. *Cythere viridis*, Müller, Entomostraca, p. 64, pl. vii., figs. 1, 2 (*non* Brady).
1853. *Cythere viridis*, Lilljeborg, De Crust. ex. Ord. tribus, p. 168, pl. xviii., figs. 4–6; pl. xix., figs. 3–5.
1854. *Cythere flavida*, Zenker, Monographie der Ostrac. (Archiv. fur Naturgesch.), p. 86, pl. iv. B.
1854. *Cythere rhomboidea*, Fischer, Abhand. d. Bayer. Acad. d. Wissensch. Bd. 7, p. 656 (*fide* Lilljeborg).
1865. *Normania grisea*, Brady, Trans. Zool. Soc., vol. v., p. 383, pl. lxi., figs. 10 *a–e*.
1868. *Loxoconcha elliptica*, Brady, Mon. rec. Brit. Ostrac., p. 435, pl. xxvii., figs. 38–39, 45–48; pl. xl., fig. 3.
1874. *Loxoconcha elliptica*, Brady, Crosskey, and Robertson, Mon. Post-tert Entom., p. 188; pl. xiv., figs. 23–25.
1885. *Loxoconcha elliptica*, Carus, Prod. Faunæ Mediterraneæ, p. 307.
1888. *Loxoconcha elliptica*, Dahl, Die Cytheriden der Westlich. Ostsee, p. 28, pl. iii., figs. 90–95, 99–106.

Additional localities.—A species restricted almost exclusively to brackish or sub-brackish situations, but in such places almost ubiquitous in the British Islands. The following are recent additions to the list of habitats:—Near the mouths of many Northumbrian rivers, and of the Humber and Deben; also in the Broads of Norfolk and Suffolk, and throughout the Fen districts; Westport, Ireland (G. S. B. and D. R.); Dartmouth Harbour; Newport, Co. Mayo (A. M. N.).

Distribution.—Sweden (Lilljeborg); Denmark (Müller); Iceland; Holland, rivers Scheldt and Maas (G. S. B.); Germany (Zenker), Cap Breton, Bay of Biscay (A. M. N.); Mediterranean (Seguenza); Finland (Cajander.); West Baltic (Dahl).

Fossil.—Scotland (Govan), Wales, (Cardiff), Sicily (Seguenza).

The form *grisea* was described from an immature *L. viridis*. Similar examples may usually be found in collections of that species which exhibit fully the various stages of growth.

4. *Loxoconcha multifora* (Norman).

1868. *Cytheropteron multiforum*, Brady, Mon. rec. Brit. Ostrac., p. 449, pl. xxix., figs. 38–42.
1874. *Loxoconcha multifora*, Brady, Crosskey, and Robertson, Mon. Post-tert. Entom., p. 187, pl. xiv., figs. 11, 12 *a*, *b*.

Though we have seen none but empty shells of this species, and are unable to assign it with certainty to any genus, we are disposed to think that its affinities are more with *Loxoconcha* than with *Cytheropteron*.

Additional localities.—Off north coast of Scotland; Cumbrae and Rothesay Bay; Budle Bay, Northumberland; off north Yorkshire coast; river Ouse, Norfolk; off Eddystone; Ilfracombe; Fowey Harbour, Cornwall; Scilly Isles; Clifden, Birturbuy, and Westport Bays, Ireland (G. S. B. and D. R.); Start Bay, Devon;

Roundstone Bay, Ireland (A. M. N.); Irish Channel and Belfast Lough (Malcomson); 150 miles off the Land's End, 200 fath. (A. M. N.).

Distribution.—Off Sartoro, Bergen Fiord, 15–40 fath.; Lervig Bay, Hardanger Fiord, Norway, 10–20 fath.; Fosse de Cap Breton, Bay of Biscay, 30–200 fath. (A. M. N.); river Scheldt, Holland (G. S. B.).

Fossil.—Ireland (Portrush).

5. *Loxoconcha pusilla*, Brady and Robertson.

(Plate xvii., figs. 24, 25.)

1870. *Loxoconcha pusilla*, Brady and Robertson, Ann. and Mag. Nat. Hist., Ser. iv., vol. vi., p. 23, pl. viii., figs. 1–3.

Carapace, as seen from the side, subrhomboidal, nearly equal in height throughout; height equal to half the length; extremities obliquely rounded; superior and inferior margins straight. Seen from above, the outline is regularly ovate, widest in the middle, extremities nearly equally acuminate, width considerably less than the height. Shell delicate and fragile, translucent, faintly rugose, and marked also with a few scattered hairs and opaque white papillæ. Length, ·4mm.

Habitat.—Montrose Basin; Firths of Forth and Clyde; Budle Bay, Northumberland; off Seaton Carew, Co. Durham, 4 fath.; rivers Wansbeck, Blyth, Deben, Ouse (Norfolk); Scheldt, Holland—scarce in all these places (G. S. B. and D. R.). Westport, Ireland (A. M. N.); two miles N.E. of Muck Island, Irish Channel, 50 fath., and several places between tide-marks in Belfast Lough (Malcomson).

Its small size and peculiar shell-structure distinguish *L. pusilla* readily from *L. elliptica* and *L. tamarindus*, with which alone it could be confounded; moreover, the young of the latter, when of the same size as *L. pusilla*, are subtriangular, one end being much narrower, while the young of the former retain the elliptical form of the adult, and are thus much higher in proportion to length than those of *L. pusilla*.

6. *Loxoconcha tamarindus* (Jones).

Synonyms: *Cythere lævata*, Norman; *Loxoconcha longipes*, G. O. Sars.

1868. *Loxoconcha tamarindus*, Brady, Mon. rec. Brit. Ostrac., p. 435, pl. xxv., figs. 45–48.

1874. *Loxoconcha tamarindus*, Brady, Crosskey, and Robertson, Mon. rec. Brit. Ostrac., p. 188, pl. viii., figs. 8–11.

1885. *Loxoconcha tamarindus*, Carus, Prod. Faunæ Mediterraneæ, p. 306.

1886. *Loxoconcha cuneiformis*, ♂ (Brady MS.), Malcomson, Recent Ostracoda of Belfast Lough, Proc. Belfast Naturalists' Field Club, p. 261, pl. xxv., figs, 1, 2.

One of the most abundant and widely-distributed of British *Loxoconchæ*; seldom,

however, in littoral situations. The long list of localities given in the "Monograph" might be supplemented by others from almost all parts of the British and Irish coasts.

Distribution.—In the Christiania Fiord, 20–30 fath., and thence to the Lofoten Islands (G. O. Sars); Lungegaards-vandet, Bergen; off Sartoro, 15–40 fath.; and other places in the Bergen and Hardanger Fiords, Norway; Cap Breton, S. W. France (A.M.N.); Messina (Seguenza); Iceland; Piræus (G. S. B.).

Fossil.—In the Crag of Suffolk (Jones). In Post-tertiary formations: Scotland, Ireland, Norway, Calabria, and Sicily.

7. *Loxoconcha fragilis*, G. O. Sars.

(Plate XVII., figs. 32–34.)

1865. *Loxoconcha fragilis*, G. O. Sars, Oversigt af Norges marine Ostracoder, p. 65.

1870. *Loxoconcha fragilis*, Brady and Robertson, Ann. and Mag. Nat. Hist., ser. IV., vol. vi., p. 24, pl. x., fig. 3.

1874. *Loxoconcha fragilis*, Brady, Crosskey, and Robertson, Mon. Post-tert. Entom., p. 189, pl. xiv., figs. 30–32.

Shell of the *female*, seen from the side, subrhomboidal; greatest height situated in front of the middle, and equal to at least half the length; anterior extremity rounded, posterior produced in the middle into a short obliquely truncated process; superior margin moderately arched over the eyes, thence sloping gently backwards; inferior sinuated in the middle, convex behind. Seen from above, compressed; greatest width situated in front of the middle, and much less than the height; posterior extremity slender and produced. Valves excessively thin and fragile, almost transparent, ornamented sparingly with very small tubercles, and but slightly hairy. Margins produced, except on the dorsum, so as to form an encircling fillet, which is marked with radiating, hair-like lines. Shell of the *male* narrower; length equal to twice the height; superior margin nearly straight and horizontal; posterior extremity obtusely rounded below. "Antennæ very slender; second joint of the superior short, much shorter than the united lengths of the two following, and shortly pilose on the anterior margin, last three joints much elongated and nearly equal; third joint of inferior antennæ very narrow, its anterior margin smooth, without any setæ. Feet very slender, second joint of the last pair about equal to the conjoined length of the two following. Copulative organs of the male obtusely produced in front. Eyes confluent." Length of female, ·5mm.

Habitat.—Montrose Basin, Greenock, and Firth of Forth, Scotland; Budle

Bay, Northumberland (G. S. B. and D. R.); off Valentia, Ireland, 112 fath. (A. M. N.).

Distribution.—Christiania Fiord; Lofoten Islands, rare (G. O. Sars; Lungegaards-vandet, Bergen (A. M. N.).

Fossil.—Scotland.

Genus VIII.—XESTOLEBERIS, G. O. Sars.

[Type, *Xestoleberis aurantia* (Baird).]

1. *Xestoleberis aurantia* (Baird).

Synonyms: *Cythere nitida*, Lilljeborg; *Cythere viridis*, Zenker.

1868. *Xestoleberis aurantia*, Brady, Mon. rec. Brit. Ostrac., p. 437, pl. xxvii., figs. 34–37; pl. xxix., fig. 6.
1874. *Xestoleberis aurantia*, Brady, Crosskey, and Robertson, Mon. Post-tert. Entom., p. 190, pl. xvi., figs. 32, 33.

Additional localities.—Cumbrae, in Firth of Clyde; Northumberland Coast, littoral but more common at the mouths of rivers; estuaries of the Fen district and Thames; off Dungeness Bay; off Eddystone and the Mumbles; Ilfracombe and Penarth Head; Scilly Isles; Dublin, Clifden, Westport, and Roundstone Bays, and Lough Swilly, Ireland (G. S. B. and D. R.); Shetland; Head of West Loch Tarbert, Argyleshire; Scarborough, Whitby, Robin Hood's Bay, and Filey Brig, Yorkshire; Start Bay, Salcombe, and off Berry Head, Devon (A. M. N.); Irish Channel, and Belfast Lough (Malcomson).

Distribution.—Norway; Christiania Fiord, and thence to Lofoten Islands (G. O. Sars); Bergen and Hardanger Fiords (A. M. N.); Sweden (Lilljeborg); Prussia (Zenker); rivers Scheldt and Maas, Holland; Franklin Pierce Bay, lat. 79° 25′ N., Capt. Feilden in Nares' Arctic Voyage (G. S. B.).

Fossil.—Scotland, South Wales, Ireland, Norway.

2. *Xestoleberis depressa*, G. O. Sars.

1850. (?) *Cytherina tumida*, Reuss, Foss. Entom. Oesterr. Tert. Beckens, p. 57, pl. viii., fig. 29.
1858. (?) *Cytheridea tumida*, Egger, Ostrak. Miocän-Schicht. Ortenburg, p. 17, pl. ii., fig. 11.
1868. *Xestoleberis depressa*, Brady, Mon. rec. Brit. Ostrac., p. 438, pl. xxvii., figs. 27–33.
1874. *Xestoleberis depressa*, Brady, Crosskey, and Robertson, Mon. Post-tert. Entom., p. 190, pl. vii., figs. 13–19.
1878. *Xestoleberis depressa*, Brady, Ostracoda of Antwerp Crag, p. 400, pl. lxvi., figs. 8 *a–d*.
1880. *Xestoleberis depressa*; Brady, Report "Challenger" Ostracoda, p. 124, pl. xxxi., figs. 1 *a–g*.
1885. *Xestoleberis depressa*, Carus, Prod. Faunæ Mediterraneæ, p. 308.

This species is so generally distributed, that it is needless to add to the list of localities given in the "Monograph." It is found all round the British coasts in depths varying from 2 to 50 fath., and even in greater depths.

Distribution.—Generally dispersed on Norwegian and Finmark coasts (G.O.Sars); Bergen and Hardanger Fiords, many places (A. M. N.); Spitzbergen (G. S. B.); Holstenbourg and Godhavn Harbours, Greenland; also in Davis Strait, lat. 69° 31′ N., long. 56° 1′ W., 100 fath., "Valorous" Exped. (A.M.N.); Bay of Biscay; Gulf of St. Lawrence (G.S.B.); Messina (Seguenza); Kerguelen Island, 20–25 fath., and lat. 52° 4′ S., long. 71° 22′ E., 150 fath., "Challenger" (G. S. B.).

Fossil.—Crag: Antwerp. Post-tertiary: Scotland, Ireland, Norway, Canada, Sicily, Calabria (Seguenza).

3. *Xestoleberis labiata*, Brady and Robertson.

(Plate XVI., figs. 27, 28.)

1874. *Xestoleberis labiata*, Brady and Robertson, Ann. and Mag. Nat. Hist., ser. IV., vol. xiii., p. 116, pl. iv., figs. 8–15.

1885. *Xestoleberis labiata*, Carus, Prod. Faunæ Mediterraneæ, p. 308.

Shell of *female*, as seen from the side, oblong, subtriangular, highest in the middle; height equal to rather more than half the length; anterior extremity narrow, sharply rounded off; posterior wide, obtusely rounded; superior margin well arched; inferior nearly straight, but produced downwards towards the posterior extremity into a bulging prominence. Seen from above, the outline is broadly ovate, tapering rapidly in front to an acute point, and very broadly rounded behind; greatest width equal to the height, and situated behind the middle. The shell of the *male*, seen laterally, is more slender and less tumid behind; seen from above, it is much more compressed and widest near the middle, the posterior extremity being somewhat narrowly rounded. The surface of the valves is smooth, distantly studded with small elevated round papillæ. The chief peculiarity of the species, however, is a remarkable labiate projection of the postero-inferior angle of the shell, which is very conspicuous on the right valve. Length, ·6 mm.

Habitat.—Scilly Islands, 14 fath. (G. S. B. and D. R.); Salcombe, Devon; Falmouth (A. M. N.).

Distribution.—Messina, Sicily (Seguenza), off the Isle of Capri, Bay of Naples, 40 fath. (A. M. N.).

Fossil.—Sicily (Seguenza).

4. *Xestoleberis margaritea*, Brady.

(Plate xvi., figs. 25, 26.)

1865. *Cytheridea margaritea*, Brady, Trans. Zool. Soc., vol. v., p. 370, pl. lviii., figs. 6 *a–d*.
1868. *Xestoleberis intermedia*, Brady, Les Fonds de la Mer, vol. i. (6me & 7me Livraisons), p. 94, pl. xii., figs. 3–7.
1880. *Xestoleberis margaritea*, Brady, Report "Challenger" Ostracoda, p. 127, pl. xxx., figs. 2 *a–g*.
1885. *Xestoleberis margaritea*, Carus, Prod. Faunæ Mediterraneæ, p. 307, ♀.
1885. *Xestoleberis intermedia*, ibid, ibidem, p. 307, ♂.

Shell of *female*, tumid; seen from the side ovate; greatest height situated behind the middle, and equal to two-thirds of the length; extremities evenly rounded; dorsal margin moderately arched; ventral slightly sinuated in front of the middle. Seen from above, the outline is broadly ovate, pointed in front, and well rounded behind; width equal to the height. End view obscurely angulated above, broad and somewhat emarginate below. Surface of valves smooth, marked with a few distant small papillæ. Colour pearly-white, with translucent or milky cloudings. Length, ·5 mm. The *male* is longer and less tumid.

Distribution.—Bay of Biscay, Marquis de Folin; Mediterranean; Mauritius (?); and by the "Challenger," Stat. 187, lat. 10° 36′ S., long. 140° 55′ E., 6 to 8 fath., off Booby Island (G. S. B.).

Our figure is drawn from a specimen dredged in the Bay of Biscay, altogether smaller and less tumid than the typical Mediterranean form, but in all other respects agreeing closely with it. The form described by Dr. Brady as *X. intermedia*, we now consider to be the male of *X. margaritea*.

Genus IX.—Cytherura, G. O. Sars.

[Type, *Cytherura gibba* (Müller).]

1. *Cytherura gibba* (Müller).

(Plate xviii., figs. 13–16, Plate xxii., figs. 6–12, and Plate xxiii., fig. 8.)

1785. *Cythere gibba*, Müller, Entomostraca, p. 66, pl. vii., figs. 7–9, ♀.
1785. *Cythere gibbera*, ibid, ibidem, p. 66, pl. vii., figs. 10–12, ♂.
1853. *Cythere gibbera*, Lilljeborg, De Crust. ex Ord. tribus, p. 167, pl. xix., figs. 1, 2, ♂.
1854. *Cythere gibba*, Zenker, Monog. der Ostrac. (Archiv. fur Naturgesch.), p. 84, pl. v., D. ♂. ♀.
1864. *Cytherura gibba*, G O. Sars, Oversigt af Norges marine Ostracoder, p. 70, ♂. ♀.
1868. *Cytherura robertsoni*, Brady, Mon. rec. Brit. Ostrac., p. 444, pl. xxxii., figs. 16–18, ♀.
1874. *Cytherura robertsoni*, Brady, Crosskey and Robertson, Mon. Post-tert. Entom., p. 221, ♂. ♀.
1880. *Cythere gibba*, Wilh. Müller, Zeits. für die Gesamm. Naturwiss. VI., p. 243, pl. v., figs. 7, 12, 13, ♂ ♀.
[*non Cytherura gibba*, Brady, Mon. rec. Brit. Ostrac.]

Shell of female subovate, height in front and behind nearly equal, greatest height subequal to half the length; anterior extremity widely rounded, dorsal

margin nearly straight in the middle portion, ventral margin sinuated. Seen from above, greatest width behind the centre. Shell of the male more elongated, oblong; seen from above, sinuated on each side about the middle of the length. Surface of valves punctate and very markedly and regularly reticulated with a network of raised lines.*

So much of the description applies both to this and the following species. *C. gibba* has the following additional characters, which distinguish it from *C. cornuta*:—

In both sexes of *C. gibba* the beak at the hinder extremity is small, and in the form of an inconspicuous central, rounded protuberance. The *female* has on each valve, just behind the middle, and projecting outwards from the ventral margin, a more or less conspicuous semiovate flattened lateral protuberance or ala. Seen from *below*, the widest part is behind the middle where the just-described lateral ala forms a rounded prominence; the outline tapers in front to a sharp extremity, while the hinder end is broadly rounded, presenting only a minute median mucronate point, so small that it can hardly be called a beak. The *male*, seen from the side, instead of the flattened semiovate lateral ala of the female, has the posterior portion of the shell regularly and evenly swollen into a rounded protuberance, in front of which a constriction passes transversely across the valves. The reticulation of the valves is much more elegantly developed in this species than in the next. Colour, greenish-black, either concolorous, which it commonly is in the female, or having a central transverse fascia, and the extremities of the shell creamy white. Length of male, ·55 mm.; of female, ·45 mm.

Habitat.—This is a typical brackish-water species, and often occurs abundantly in places where the admixture of saline ingredients is very slight. The following partial list of habitats will suffice to show its wide distribution:—River Clyde at Greenock; Montrose Basin; near the mouth of several Northumberland rivers; in the rivers Deben, Stour, and Ouse; in many of the Norfolk Broads; brackish pond at Westport, Co. Mayo; canal at Belfast (G. S. B. and D. R.); Head of West Loch Tarbert, Argyleshire; Seaton Sluice, Northumberland; Dartmouth Harbour; Newport, Ireland (A. M. N.); ? Irish Channel (Malcomson).

Distribution.—Norway (G. O. Sars); Sweden (Lilljeborg !); Denmark (Müller); Prussia (Zenker); Pomerania (Wilh. Müller !); Finland (Cajander); rivers Scheldt and Maas, Holland (G. S. B.).

Fossil.—Scotland (Loch Gilp), Norway.

* It is worth notice that the central areola, so characteristic of the shells of almost all *Cytherura*, is not a mere pigment patch, but consists of denser and more resistant tissue than the rest of the valve—perhaps a sort of defensive buckler over the central part of the animal. It offers more mechanical resistance to pressure, and is less easily acted on by chemical re-agents. When treated with acid it is often left entire after the rest of the shell has disappeared.

2. *Cytherura cornuta*, Brady.

(Plate XVIII., figs. 21, 22.)

1868. *Cytherura cornuta*, Brady, Mon. rec. Brit. Ostrac., p. 445, pl. xxxii., figs. 12–15 ♀.
1868. *Cytherura gibba*, idem, ibidem, p. 444, pl. xxxii., figs. 68–70, ♂ (*non C. gibba*, Müller).
1868. *Cytherura affinis*, idem, ibidem, p. 443, pl. xxxii., figs. 19–21, ♀ variety (*vix C. affinis*, Sars).
1868. *Cytherura lineata*, idem, ibidem, p. 441, pl. xxxii., figs. 30–34, 67 (*junior*).
1874. *Cytherura cornuta*, Brady, Crosskey, and Robertson, Mon Post-tert. Entom., p. 199, pl. xiii., figs. 23–25, ♀.
1874. *Cytherura gibba*, iidem, ibidem, p. 198, pl. xiii., figs. 26–29, ♂.
1878. *Cytherura cornuta*, Brady, Ostracoda Antwerp Crag, Zool. Trans., vol. x., p. 402, pl. lxvi., figs. 9 *a–k*.
1885. *Cytherura cornuta*, Carus, Prod. Faunæ Mediterraneæ, p. 309.

The male of this species was mistaken in the "Monograph" for that of *C. gibba*, Müller, but the true *C. gibba* is the last species, which has generally been known in this country as *C. robertsoni*.

The *female*, viewed laterally, is not unlike that of *C. gibba*, from which it may be distinguished by the following characteristics. The posterior beak is much more pronounced, and forms a large angular process situated rather above the middle of the posterior extremity. There is no semi-ovate lateral ala, as in *C. gibba*, but instead of this the ventral margin is acute, and at a short distance above it on the side is a longitudinal rib, which, sometimes in the adult and always in the young, terminates posteriorly in a spinous point. The outline, seen from below, is pretty evenly ovate, the widest part being, if anything, in front of the middle; posterior extremity narrow, and having a conspicuous large central beak. The *male* is distinguished from that of *C. gibba* by the keel or rib, which, as in the female, runs along the side a little within the ventral margin, but does not end in a spine; the protuberance on the hinder part of the shell is more prominent and boss-like than in the female; the depression anterior to this commences above the boss, and thence passes obliquely forwards and downwards; the posterior rostrate process is much larger, and situated above the middle: seen from below, the outline is cuneiform, the greatest breadth being close to the posterior extremity; just in front of the rostrum the boss on each side projects beyond and conceals the rib. Length of female, ·40 mm.; of male, ·45 mm.

Cytherura lineata of the "Monograph" is the young condition of this species. In early stages the outline approaches more and more towards a triangular form as the age is less, the lateral rib terminates behind in a spine, and the surface sculpture consists of longitudinal striæ instead of the reticulation of the mature animal.

Additional localities.—Off the North coast of Scotland; Loch Fyne, Loch Ryan, and many places in the Firth of Clyde; off the Scilly Isles; Dublin, Westport,

Clifden, and Roundstone Bays, and Mulroy Lough, Ireland ; between tide-marks at Boulmer, Northumberland (G. S. B. and D. R.); Unst Haaf, Shetland; the Minch; Inverary; Berwick-on-Tweed; Salcombe, Devon (A. M. N); Irish Channel, and Belfast Lough (Malcomson).

Distribution.—Dardanelles (G. S. B.).

Fossil.—Scotland, Ireland, Norway.

3. *Cytherura affinis*, G. O. Sars.

(Plate XVIII., figs. 19, 20.)

1865. *Cytherura affinis*, G. O. Sars, Oversigt af Norges marine Ostracoder, p. 77.

Shell, seen from the side, somewhat oblong, greatest height not quite equal to half the length; anterior margin very broadly and evenly rounded; posterior produced into a well-pronounced beak, which is situated above the middle, and has its termination obliquely truncate; dorsal margin forming a very low and depressed arch, with a very slight angularity in front of the middle; ventral margin scarcely concave, the concavity evidenced chiefly in front where at its junction with the anterior margin an angularity is formed. Valves very tumid below, where they are projected outwards and form a sharply-keeled edge; from this point of greatest tumidity the sides abruptly converge, like the gable of a house, and meet acutely above; just in front of the middle in the region of the lucid spots, which form a transverse row and are unusually near the ventral margin, there is a slight transverse depression. Surface of valves more or less reticulated, and sculptured with round puncta, which have a tendency to arrange themselves in longitudinal lines. Seen from above, the outline is elongated-subovate, the width fully equal to the height, the sides somewhat flattened, and obscurely sinuated in the position of the transverse furrow already described; in front the extremity is pointed, the sides, rather rapidly and flatly converging, form at their union an angle of about 80 degrees; behind they arcuately converge, and the rostrum forms a mucronate projection. Seen from below, the base is very broad and remarkably flat, and sculptured with longitudinal striæ. Length, ·6 mm.

Distribution.—As yet only known in Scandinavia, Öxfiord, Finmark (G. O. Sars), Dröbak, Christiania Fiord, 120 fath.; and off Midso Lighthouse, Hardanger Fiord, 50–100 fath. (A. M. N.).

Fossil.—Norway (G. O. Sars).

The young differ from the adult in being less high in proportion to the length, the beak more central, the lateral ridge terminating behind in a spine-point, the surface much more strongly reticulate than in the adult, and the riblets more raised. It

reminds us of the young of *C. cornuta* (= *C. lineata*, Brady), but is higher in proportion to the length, and the sculpture different.

The shorter, higher, and more roundedly ventricose *C. affinis* of Brady, *Mon. Pl.* xxxii., *figs.* 19–21, is not the present species, but a variety of *C. cornuta* in which the lateral rib is not developed behind.

4. *Cytherura sella*, G. O. Sars.

(Plate XVIII., figs. 3–6.)

1865. *Cytherura sella*, G. O. Sars, Oversigt af Norges marine Ostracoder, p. 73, ♂ ♀.
1868. *Cytherura cuneata*, Brady, Mon. rec. Brit. Ostrac., p. 442, pl. xxxii., figs. 35–38, 63, ♂.
1869. *Cytherura flavescens*, Brady, Ann. and Mag. Nat. Hist., ser. IV., vol. iii., p. 49, pl. viii., figs. 13–15 ♀.
1869. *Cytherura flavescens*, idem, ibidem, vol. iii., p. 391, pl. xx., figs. 13, 14.
1874. *Cytherura flavescens*, Brady, Crosskey, and Robertson, Mon. Post.-tert. Entom., p. 193, pl. xi., figs. 43–46 and pl. xvi., figs. 7, 8.
1874. *Cytherura cuneata*, iidem, ibidem, p. 196, pl. xi., figs. 42–47 ; pl. xii., fig. 15 ; pl. xiii., figs. 36, 37.
1885. *Cytherura cuneata*, Carus, Prod. Faunæ Mediterraneæ, p. 309.

Female.—The lateral view is rhomboidal, but the height is equal to just half the length, and the posterior beak is less prominent than in the male. Seen from above, the shape is ovate, widest in the middle and tapering towards each extremity, width decidedly less than half the length, anterior extremity acuminate, posterior mucronate. The surface-sculpture is generally similar to that of the male, but the lattice-work is much coarser, and the interspaces are not so delicately punctated. Length, ·43 mm.

Male.—Shell, seen from the side, subrhomboidal, height nearly equal throughout, scarcely equal to half the length ; anterior extremity obliquely rounded ; posterior produced about the middle into a short truncated or obtusely rounded beak, sinuated below the middle ; superior margin almost straight or very feebly arched ; inferior straight. Seen from above, the outline is wedge-shaped, greatest width situated near the posterior extremity and equal to the height ; subacuminate in front, broadly mucronate behind. The surface is marked with distinct but delicate longitudinal ribs and with sinuous cross bars, which are somewhat irregular in distribution ; the interspaces of the reticulations are finely punctate, this pattern being best seen on the posterior tuberosities of the shell. Length, ·48 mm.

Specimens described in the "Monograph," as the female *C. cuneata*, are really only a less slender form of the male. The true female had not then been seen, and the few specimens of the female first subsequently found—lacking some of the most conspicuous characters of the male as to shape and sculpture—were erroneously

referred to a new species, under the name of *C. flavescens*. The large series of specimens which have of late years come under our observation leave no room to doubt the identity of the two forms, and wherever one occurs in abundance the other is sure to be found in equal numbers.

Cytherura sella occurs plentifully all round the British Islands, ranging from a depth of thirty fathoms or more up to low-water mark. It occurs also frequently in estuarine situations.

Distribution.—Christiania Fiord, 3–8 fath., rare (G. O. Sars); Lervig Bay, Stordöen, and Stoksund, 126 fath. (A. M. N.); Iceland; rivers Scheldt and Maas, Holland (G. S. B.); Fosse de Cap Breton, Bay of Biscay, 180–200 fath. (A. M. N.); Eastern Mediterranean, Smyrna (G. S. B.).

Fossil.—Scotland.

5. *Cytherura acuticostata*, G. O. Sars.

1868. *Cytherura acuticostata*, Brady, Mon rec. Brit. Ostrac., p. 445, pl. xxxii., figs. 1-11.
1874. *Cytherura acuticostata*, Brady, Crosskey, and Robertson, Mon. Post-tert Entom., p. 199, pl. xvi., figs. 1-3.
1885. *Cytherura acuticostata*, Carus, Prod. Faunæ Mediterraneæ, p. 311.

One of the commonest and most widely distributed species of the genus, varying, however, very considerably in external appearance, so far as that depends on the development of the characteristic surface-ridges and their spines.

This is one of the commonest and most abundant of British ostracoda, and must be looked upon as a purely marine form, notwithstanding its occurrence in such estuarine situations as the rivers Blyth, Humber, and Ouse, and even in fresh water at Whittlesea Dyke. Its usual habitat is in the sea, ranging from about 4 fathoms downwards. It is found at all points of the British coasts.

Distribution.—Christiania Fiord (G.O. Sars); Oster Fiord; Batalden, near Floro; Bergen Fiord; Lervig Bay (A. M. N.); Messina (Seguenza); off Capri, Bay of Naples (A. M. N.).

Fossil.—Scotland (Oban), Ireland (Belfast), Norway.

6. *Cytherura striata*, G. O. Sars.

(Plate xviii., figs. 17, 18.)

1868. *Cytherura striata*, Brady. Mon. rec. Brit. Ostrac., p. 441, pl. xxxii., figs. 26–29, 62, 64, 65, ♂.
1868. *Cytherura quadrata*, Norman, Last Report Dredging among the Shetland Isles, Brit. Assoc. Report., p. 292, ♀.
1872. *Cytherura quadrata*, Brady and Robertson, Ann. and Mag. Nat. Hist., ser. iv., vol. ix., p. 55, pl. i., figs. 10, 11.
1874. *Cytherura quadrata*, Brady, Crosskey, and Robertson, Mon. Post-tert. Entom., p. 195, pl. xi., figs. 38–41.
1874. *Cytherura striata*, iidem, ibidem, p. 196, pl. xiii., figs 34, 35.
1885. *Cytherura striata*, Carus, Prod. Faunæ Mediterraneæ, p. 310.
1885. *Cytherura quadrata*, idem, ibidem, p. 311.

The female (*C. quadrata*, Norman) differs from the male in being shorter and higher, the ventral margin quite straight, the ala more developed, and the shell more tumid, and when seen from above its greatest width is situated towards the anterior extremity.

This is one of the commonest of the *Cytheruræ*, occurring in tidal pools, as well as in all depths of water round the British coasts, and extending commonly into the estuaries of rivers on the east coast of England and in Holland. G. S. B. and D. R. have found it also in freshwater dykes at Whittlesea. Any complete list of habitats would have to include almost all our marine dredgings.

Distribution.—Christiania Fiord, 3–8 fath. (G. O. Sars); Dröbak, 30–120 fath.; Haakelsund, Kors Fiord, 3–10 fath., and Lervig Bay, 10–25 fath., Norway (A. M. N.); rivers Scheldt and Maas, Holland (G. S. B.); Messina (Seguenza); Naples (A. M. N.).

Fossil.—Scotland, South Wales, Ireland, Norway, Canada, and Calabria.

7. *Cytherura exserta*, n. sp.

(Plate xx., figs. 24, 25.)

Shell, seen from the side, oblong; height nearly the same throughout, equal to two-fifths of the length; anterior margin broadly and evenly rounded, greatest protrusion central; posterior extremity with a very short beak situated slightly above the middle, its termination broadly truncate; dorsal and ventral margins subparallel, the former arcuately declining in front, while the hinder slope is scarcely convex; the latter slightly concave. Valves compressed at the extremities, very

tumid throughout their central portion, but having a slight depression towards the dorsal margin just in front of the middle, surface sculptured with longitudinal riblets. Seen from above, the aspect is unlike that of any other *Cytherura*, the central portion forms a short and very broad oval, the sides of which are very convex; greatest width much exceeding the height, and equal to more than half the length; beyond this oval the extremities are alike, the sides suddenly converging are projected forwards (or backwards) and form mucronate points. Length, ·30 mm.

This is a very minute species, with strongly marked characters. Small as the size is, the shells have nothing of the appearance of immaturity, but are strongly calcareous.

Habitat.—Two specimens, dredged in 126 fath., in Stoksund, near the mouth of the Hardanger Fiord, Norway, in 1879 (A. M. N.).

8. *Cytherura angulata*, Brady.

(Plate XIX., figs 7, 8.)

1868. *Cytherura angulata*, Brady, Mon. rec. Brit. Ostrac., p. 440., pl. xxxii., figs. 22–25.
1870. *Cytherura insolita*, Brady, Nat. Hist. Trans. Northumberland and Durham, vol. iii., p. 371, pl. xiii., figs. 11, 12 (*monstrositas*).
1874. *Cytherura angulata*, Brady, Crosskey, and Robertson, Mon. Post-tert. Entom., p. 197, pl. xii., fig. 14; pl. xi., figs. 48–51.

C. angulata occurs in dredgings from all parts of the British Seas, and in all depths of water from tide-marks to 30 fathoms; numerically, however, it is not by any means so common as many other species of *Cytherura*.

Distribution.—Norway, in the following places—Lervig, Stordöen, 3–25 fath.; Stoksund, 126 fath., and Dröbak, 30–100 fath. (A. M. N.); rivers Scheldt and Maas, Holland (G. S. B.).

Fossil.—Scotland, South Wales (Cardiff), Ireland, Norway.

9. *Cytherura atra*, G. O. Sars.

(Plate XVII., figs. 22, 23.)

1865. *Cytherura atra*, G. O. Sars, Oversigt af Norges marine Ostracoder, p. 75.
1874. *Cytherura similis*, Brady, Crosskey, and Robertson, Mon. Post-tert. Entom., p. 192 (*partim*), pl. xi., figs. 16–18.

Shell of *female*, seen from the side, obliquely quadrangular, or subrhomboidal; greatest height sub-equal to half the length; anterior margin obliquely rounded, posterior obliquely truncate, or produced above the middle into a very short and

obtuse process; dorsal margin evenly arched; ventral gently sinuated, with an obtuse posterior angle. Seen from above, the form is ovate, greatest breadth situated behind the middle, rather less than the height, gradually attenuated in front and behind. Surface of valves distinctly and somewhat regularly reticulated, no median areola. The whole shell remarkable for its deep black colour. Antennæ and antennules more robust than usual, terminal joint of the antennules very short. Terminal nail of feet moderately large and strong; second joint of last pair rather longer than combined length of two following joints. *Male* unknown. Length, ·51 mm.

Habitat.—Very rare in the Lofoten Islands, in 3–8 fath. (G. O. Sars).

The above is Sars' description of the species, and the figures are taken from one of his specimens in the collection of A. M. N.

Fossil.—Post-tertiary: Scotland (Loch Gilp, Barrie, &c.).

10. *Cytherura undata*, G. O. Sars.

(Plate xix., fig. 12 (*junior*).)

Synonym: *Cytherura humilis*, Brady.

1868. *Cytherura undata*, Brady, Mon. rec. Brit. Ostrac., p. 443, pl. xxxii., figs. 43–49, 66.
1868. *Cytherura pumila*, Norman, Last Report Dredging among the Shetland Isles, Brit. Assoc. Report, p. 392 (name only).
1874. *Cytherura undata*, Brady, Crosskey, and Robertson, Mon. Post-tert. Entom., p. 194, pl. xi., figs. 9–15; pl. xii., fig. 17.
1874. *Cytherura pumila*, iidem, ibidem, p. 193, pl. xii., figs. 33–35 (*junior*).

A widely-distributed species, occurring in moderate depths of water all round the islands, and reaching into the estuaries of rivers on the Northumberland coast; rarely found between tide-marks, but scarcely ever missing in dredged material from the British coasts.

Distribution.—Christiania Fiord, 3–8 fath., and thence to Finmark (G. O. Sars); Batalden, near Floro, 200 fath.; Dröbak, 120 fath.; Lervig Bay, 10–25 fath.; Stoksund, 126 fath.; Bukken, in Bergen Fiord, 40 fath. (A. M. N.); river Scheldt, Holland; Spitzbergen; Cumberland Inlet; Baffin's Bay, lat. 66° 10′ N., long. 67° 15′ W., 15 fath. (G. S. B. and D. R.): "Valorous" Expedition, Holsteinborg Harbour, 10 fath., and Davis Strait, Stat. 3, lat. 69° 31′ N., long. 56° 1′ W., 100 fath. (A. M. N.); Franklin-Pierce Bay, 13–15 fath., Capt. Feilden, in Nares' Arctic Voyage; Gulf of St. Lawrence (G. S. B.).

Fossil.—Scotland, Ireland, Norway, Canada.

We have come to the conclusion that *Cytherura pumila* of the Post-tertiary Monograph, which we here figure (Pl. xix., fig. 12), must be regarded as the young of this species. It has a very different shape from the adult; the surface is densely punctate all over; at first one or two slight folds appear, and these

gradually increase in size and number, until the strongly ribbed state of the adult is attained. With the development of the ribs, there at the same time takes place an overgrowth on all parts of the surface, which entirely obliterates all traces of the punctation characteristic of the young shell.

11. *Cytherura producta*, Brady.

(Plate XIX,, figs. 5, 6.)

1868. *Cytherura producta*, Brady, Mon. rec. Brit. Ostrac., p. 443, pl. xxxii., figs. 60, 61.
1874. *Cytherura producta*, Brady, Crosskey, and Robertson, Mon. Post-tert. Entom., p. 198, pl. xiii., figs. 30–33.

Additional localities.—This is one of the less common species, occurring usually in small numbers. Additional localities are Firth of Clyde, in several places; off the coasts of Durham and North Yorkshire; Dungeness Bay; off Eddystone Lighthouse; in the rivers Aln and Thames; the Scilly Isles; Westport and Roundstone Bays, and Mulroy Lough, Ireland (G. S. B. and D. R.); Bressay Sound, Shetland, tide-marks; off Tarbert, Loch Fyne, 25 fath. (A. M. N.); Irish Channel, and Island Magee, near Belfast (Malcomson).

Distribution.—Off Sartoro, Bergen Fiord, 15–40 fath.; and Lervig Bay, Stordöen, Norway (A. M. N.); river Scheldt, Holland (G. S. B.).

Fossil.—South Wales (Cardiff New Dock Basin).

12. *Cytherura grœnlandica*, n. sp.

(Plate XVIII., figs. 23, 24.)

Shell, seen from the side, somewhat peach-stone shaped; greatest height central, more than half the length; anterior margin subtruncate, or even slightly emarginate, most produced below the middle; posterior extremity with a well-pronounced, sub-central beak, which has its termination obliquely truncate; dorsal margin boldly arched, anterior declination much arched, posterior slope scarcely convex; ventral margin slightly sinuated in front, no angulation at its junction with the anterior margin, the margin behind the anterior sinuation is boldly convex. Valves moderately, and tolerably evenly convex, without angularity below, and not forming an acute ridge at their junction dorsally, as is the case in *C. affinis*, which the present resembles in its combination of reticulation and punctation of the surface sculpture. Seen from above, the greatest width, which is much less than the height and sub-equal to two-fifths of the length, is posterior, the sides thence at first very slowly, but at two-thirds the length more

rapidly but still gradually converge, in such a way that the anterior extremity is conical, with well-rounded and wide termination; behind the valves converge with an abrupt arcuation, and the rostrate process forms a small mucro. Viewed from below, the base is of moderate width, not flattened, and rounded at the sides. Length, ·45 mm.

Habitat.—Holsteinborg Harbour, Greenland, 10 fath., "Valorous" Expedition, 1875 (A. M. N.); off Cape Frazer, 80 fath., Captain Feilden, in Nares' Arctic Expedition (G. S. B.).

In dorsal outline *C. grœnlandica* resembles most closely *C. sella* ♂; but the lateral aspect and style of surface sculpture is altogether different. In surface sculpture it resembles *C. affinis*, but in lateral and dorsal aspects, and especially in the different kind of tumidity of the shell and absence of flattened ventral surface, it is far removed from that species. Lastly, as regards the lateral view, it assimilates rather closely to *C. concentrica*, but the very peculiar dorsal form is different.

13. *Cytherura nigrescens* (Baird).

(Plate xix., figs. 1, 2.)

1868. *Cytherura nigrescens*, Brady, Mon. rec. Brit. Ostrac., p. 440, pl. xxxii., figs. 50–56; and pl. xxxix., fig. 7.

1874. *Cytherura nigrescens*, Brady, Crosskey, and Robertson, Mon. Post-tert. Entom., p. 192; pl. xi., figs. 28–32; and pl. xii., fig. 13.

1888. *Cytherura nigrescens*, Dahl, Die Cytheriden der Westlich, Ostsee, p. 30, pl. iii., figs. 107–109; pl. iv., figs. 110–114.

This species is found all round the British shores, ranging from tide-marks down to depths of at least 30 fathoms. It occurs also commonly in estuarine situations near the mouths of rivers, notably in those of Holland and the East Coast of England, and we have found it also in freshwater dykes at Whittlesea.

Distribution.—Sars says that it is found everywhere living upon algæ, near the shore of Norway—a statement which we (A. M. N.) can fully confirm; rivers Scheldt and Maas; Holland (G. S. B.); Fosse de Cap Breton, Bay of Biscay (A. M. N.).

Fossil.—Scotland, England, Ireland, Norway, and Canada.

14. *Cytherura simplex*, n. sp.

(Plate xviii., figs. 1, 2.)

1872. *Cytherura simplex* (name only), Brady and Robertson, Ann. and Mag. Nat. Hist., ser. iv., vol. xi., p. 66.

1874. *Cytherura sarsii* ("local variety"), idem, ibidem, vol. xiii., p. 117, pl. iv., figs. 6–7.

Shell of *male* (?), seen from the side, greatly elongated, siliquose, of nearly equal height throughout, height to length as three to eight; anterior extremity well

rounded, without angularity above or below, greatest projection central; posterior extremity much narrower, not beaked, subtriangular, apex of triangle (*i. e.* extremity) central, obtuse, and rounded; dorsal margin forming a much depressed arch throughout, posterior declination rather steeper than the anterior; ventral margin slightly incurved throughout all its anterior portion, the sinuation closely corresponding in arcuation with the dorsal margin, at one-fourth of the length from behind an angularity is produced by the ventral margin here sweeping upwards and backwards without curvature to the extremity. Seen from above, the form is narrowly boat-shaped, the sides subparallel, the breadth less than the height and equal to one-third only of length; anterior extremity, or "bows," moderately sharp; posterior, or "stern," broadly rounded. Valves glassy and pellucid; the angulation of the ventral margin is made more evident from the fact that there is here a minute plica just within the edge, which plica sometimes terminates in a microscopic spine-point; central areola very narrow, occupying a much smaller part of the valves than in the allied species *C. nigrescens*, *C. similis*, and *C. rudis*, margined by an opaque white line, its front edge commences dorsally at one-fourth of length from anterior extremity, and passes downwards at first nearly transversely, then bends suddenly with a flexuous wave obliquely backwards, the areola behind is deeply and widely emarginate, so that its lower and posterior portion is tongue-shaped; from this tongue and from the front edging line numerous opaque hair-like lines radiate through the substance of the shell. Length, ·5 mm.

Habitat.—St. Ninian's Bay, Isle of Bute; river Ouse; Thames Estuary, 7 fath.; off St. Mary's, Scilly Islands, 10–12 fath.; Birturbuy Bay, Ireland (G. S. B. and D. R.); off Fairlie, Firth of Clyde (A. M. N.); Belfast Lough, Dr. Malcomson (G. S. B.).

15. *Cytherura concentrica*, Brady, Crosskey, and Robertson.

(Plate XVII., figs. 28, 29; Plate XIX., figs. 3, 4.)

1868. *Cytherura concentrica* (?), Norman, Last Report Dredging among the Shetland Isles, Brit. Assoc. Report, p. 292 (name only).

1874. *Cytherura concentrica*, Brady, Crosskey, and Robertson, Mon. Post-tert. Entom., p. 194, pl. xi., figs. 7, 8; and pl. xv., fig. 21.

Shell somewhat peach-stone shaped, highest in the middle, height equal to half the length; anterior extremity broadly and obliquely rounded, most produced below the middle; posterior extremity formed by the dorsal and ventral margins equally and without angularity converging, and ultimately forming a short, obtuse, central beak; dorsal margin boldly arched, the arch more steep in front, where it

sweeps down almost to the infero-anteal rounded corner; ventral margin slightly sinuated in front of the middle. Seen from above, compressed, acuminate in front, sharply and strongly mucronate behind; width rather less than half the length. Shell-surface concentrically striated round the sides of the valves, the central portion of which is finely punctate or sculptured with little quadrangular or irregularly-sided cells. This is the more general ornamentation of the fossil specimens. In recent specimens the surface of mature shells is usually more smooth, sparingly punctate, the anterior part of the shell with a few longitudinal striæ, the posterior sometimes exhibiting more or less traces of concentric striation. Immature shells minutely punctate all over, the puncta running in lines which have a tendency to concentric arrangement especially round the margins. Length of fossil specimens, ·6 mm. Length of recent specimens, ·35 mm. Length of punctate young, ·30 mm.

Some very small *Cytheruræ*, with closely punctate surface—the punctation assuming a concentric disposition round the margins—have been regarded by us as the young of the present species, and were recorded by Dr. Norman in his Shetland Report. The same form has since been met with in several other places on the British coast, and is figured in Plate x., figs. 28, 29. No unmistakable *C. concentrica*, closely agreeing with the fossil types, have been found in our seas. The small form must for the present be left in doubt.

We at present assume that these represent different conditions of our species, and the two forms have been found together off Fairlie, in the Firth of Clyde, but the larger recent specimens known to us are of somewhat less size than the fossil, and the beak is not quite so much produced. The small specimens might have been supposed to be the young of *C. nigrescens*, but we have not found intermediate links; while the difficulty is increased by another form known to us, and often found in company with these punctate specimens, which differs slightly in outline, and is devoid of the surface ornament; and this latter form looks more like the young of *C. nigrescens.*

British localities.—Among *Laminariæ*, in 5–7 fath., Bressey Sound, Shetland; the Minch; off Fairlie, Firth of Clyde; Seaton Delaval, Northumberland; Hartlepool; Robin Hood's Bay, Yorkshire; Salcombe, Devon (A. M. N.).

Distribution.—Lervig Bay, 10–25 fath.; off Batalden, near Floro; Stoksund, 80–100 fath., Norway (A. M. N.); Gulf of St. Lawrence; off Spitzbergen; off Cape Frazer, 50–80 fathoms, Capt. Feilden, in Nares' Arctic Voyage; and in lat. 73° 10′ N., long. 53° 0′ E. (G. S. B.).

Fossil.—Scotland.

16. *Cytherura similis*, G. O. Sars.

(Plate XVIII., figs. 7–9.)

1865. *Cytherura similis*, G. O. Sars, Oversigt af Norges marine Ostracoder, p. 72, ♀.

1868. *Cytherura sarsii*, Brady, Mon. rec. Brit Ostrac., p. 442; pl. xxxii., figs. 39–42, ♂.

1870. *Cytherura propinqua*, Brady and Robertson, Ann. and Mag. Nat. Hist., ser. IV., vol. v., p. 24, pl. x., figs. 1, 2, ♀.

1874. *Cytherura sarsii*, Brady, Crosskey, and Robertson, Mon. Post-tert. Entom., p. 197, pl. xi., figs. 24 27; pl. xiii, figs. 18, 19, ♂.

1874. *Cytherura similis*, idem, ibidem, p. 192 (partly, but not figures),* ♀.

Female very like *C. nigrescens*, but larger, as well as differing in other particulars. Shell, seen from the side, subovate; greatest height central, more than equal to half the length; anterior extremity evenly rounded; posterior extremity with the beak very short, much less prominent than in *C. nigrescens* and obtusely rounded; dorsal margin boldly and evenly arched; ventral slightly concave. Seen from above, more tumid than *C. nigrescens*, ovate, width equalling half the length. End-view ovate, tumid, widest towards the base, width and height equal. Surface of valves smooth, or obscurely reticulated at the extremities, and rarely all over the shell; median areola in form as that of *C. nigrescens*, obtusely angulated in front, and slightly emarginate behind. "Last joint of antennules very short, the three preceding subequal in length to each other. Nail of the feet of moderate length. Second joint of last foot equal to the combined length of the two following joints" (Sars). Length, ·55 mm.

Male.—Oblong, subquadrangular, of nearly equal height throughout, height not equal to half the length. Outline as seen from above more compressed, long-ovate, widest behind the middle, width considerably less than the height, sides flattened in their central portion, gradually converging and acuminate in front, much more rapidly converging and submucronate behind. End view broadly ovate; widest in the middle; in other respects as the female. Length, ·55 mm.; of about the same length, but less high than female.

Habitat.—Öyster-ooze, Stranraer; Dublin Bay, 3–4 fath.; Rothesay Bay, 10–12 fath. (G. S. B. & D. R.), off the Mumbles, 2–3 fath. (G. S. B.).; off Fairlie, Firth of Clyde; off Skipness, Loch Fyne, 40 fath.; Seaton-Delaval, Northumberland, tide-marks (A. M. N.).

Distribution.—Very rare, Langesund, Norway; Öxfiord, Finmark (G. O. Sars); Dröbak, 120 fath.; Haakelsund, Kors Fiord, Norway, 3–10 fath. (A. M. N.); Smith Sound, lat. 78° 57′ N., Capt. Feilden in Nares' Arctic Voyage (G. S. B.).

Fossil.—Post-tertiary: Scotland, Ireland; Norway.

* See under *Cytherura rudis* and *C. atra*.

17. *Cytherura rudis*, Brady.

(Plate xviii., figs. 10–12; Plate xix, fig. 21.)

1868. *Cytherura rudis*, Brady, Ann. and Mag. Nat. Hist., ser. iv., vol. ii., p. 34, pl. v., figs. 15–17.
1871. *Cytherura granulosa*, Brady and Crosskey, Ostracoda from Post-tert. deposits of Canada and New England, Geological Magazine, vol. viii., p. 5, pl. ii., figs. 14, 15, ♂.
1871. *Cytherura cristata*, idem, ibidem, p. 6, pl. ii., figs. 12, 13, ♀.
1874. (?) *Cytherura similis*, Brady, Crosskey, and Robertson, Mon. Post-tert. Entom., pl. xii., fig. 16.

Shell of *female*, seen from the side, oval, greatest height central; equal to more than half the length, the height nearly equal throughout the greater part of the length; anterior extremity very broadly rounded, greatest protrusion below the middle, the arcuation being long and bold; posterior extremity much narrower, somewhat exserted centrally, but not beaked, slopes above and below this narrowly rounded centre, very slightly arched; dorsal margin boldly arched at the extremities, slightly flattened in the central third of its length; ventral margin very slightly sinuated centrally, and obtusely angled at the juncture with the upward slope behind. Seen from above, with subparallel sides, width less than height, sides suddenly converging behind, more gently in front. Surface of valves nearly smooth, in some specimens, recent as well as fossil; within the inferior border there is a very slightly elevated crescentiform ridge, which is extended partly round the posterior margin. Shell of *male*, seen from the side, elongated, elliptical, twice as long as broad, of nearly equal height throughout; anterior extremity very broadly and evenly rounded, as in the female; the greatest protrusion below the middle posterior and ventral margins, as in the other sex; dorsal margin nearly straight throughout the greatest part of its length, and remarkably subparallel to the ventral. Outline seen from above, subcuneiform, widest at the posterior extremity, where the valves converge with steep declivity, and their lips protrude mucronately; sides flattened, very slightly converging forward throughout the greater part of their length, but ultimately more suddenly, the extremity being narrow, but blunt. Length of male, ·525 mm.; of female, ·5 mm.

The granulose appearance of the surface is characteristic of old and somewhat worn shells, but not of living examples.

The specimen here figured and described represents the adult, but not aged shell. In some specimens the crescentic ridge figured in the type of *C. cristata*, Brady, is present; in others scarcely a trace of it can be seen. The type of *C. rudis*, Brady, is an aged specimen, in which the shell is much thickened, the crescentic ridge strong, and the surface sculptured with large cells, which are for the most part quadrangular, and also some transverse riblets, and this specimen is abnormal

in having the posterior extremity more produced and rostrate than usual; but on the same mounting are others which are exactly in form as the typical *C. cristata,* and the surface sculptured, though less coarsely, as in the typical *C. rudis.* We are disposed to refer to this species, also the ostracod which is figured on Plate XII., fig. 16 of the *Monograph of the Post-tertiary Entomostraca,* as *Cytherura* (*similis ?*), from the deposit at Loch Gilp; though in the recent specimens which have come under our notice we have not observed similar strongly pronounced longitudinal riblets.

Great difference of sculpture is similarly found to prevail in the female of *C. sella,* where hardly two specimens can be found alike, since sometimes it has a quite smooth surface, at others very elaborate and varied ornamentation.

We cannot doubt that the above characterized forms are sexes of one species; both in fossil and recent state they have been found together, and the differences are of similar character to those to be observed in the sexes of other species of *Cytherura.*

Habitat.—Godhavn Harbour, Greenland, 5–25 fath., "Valorous" Expedition, 1875 (A. M. N.); Ginevra Bay, Spitzbergen, Mr. Lamont; Smith Sound, 78° 37′ N., 210 fath., Captain Feilden, in Nares' Arctic Expedition (G. S. B.).

Fossil.—In Post-tertiary deposits at Portland, Co. Maine (Brady and Crosskey); Scotland (Loch Gilp) ?.

18. *Cytherura fulva,* Brady and Robertson.

(Plate XIX., figs. 9–11.)

1874. *Cytherura fulva,* Brady and Robertson, Ann. and Mag. Nat. Hist., ser. IV., vol. xiii., p. 116, pl. iv., figs. 1–5.

Shell of the *female* very tumid; seen laterally subquadrate, broadly rounded in front, produced behind into an obscure rounded subcentral beak; superior margin evenly and very slightly rounded, sloping steeply backwards towards the posterior extremity; inferior nearly straight, sinuated in front of the middle; greatest height situated in the middle and equal to rather more than half the length. Seen from below, the outline is very broadly ovate, widest in the middle, the width being somewhat greater than the height; anterior extremity broadly rounded, with a distinct central mucro, posterior also broad, but tapering to a subacuminate central point. Shell of the *male,* seen laterally, much more elongated, with nearly straight dorsal and ventral margins, the height equal to scarcely half the length; the outline, as seen from below, is also much more compressed. Surface of the shell obscurely reticulated and dotted, marked also especially on the inferior surface with faint longitudinal furrows. Length, ·5 mm.

Habitat.—*C. fulva* was dredged pretty abundantly on a bottom of hard granitic sand, in a depth of 10–40 fath., off St. Mary's and St. Agnes (Scilly Islands), and more recently in depths of 20 and 30 fath., off the Durham Coast; Dungeness Bay, 7 fath.; Fowey Harbour, 3 and 4 fath.; off the Eddystone Lighthouse; in the river Ouse; between tide-marks at Boulmer, Northumberland, Clifden Bay, Ireland (G. S. B.); Loch Fyne; Stromness Bay; and Greenock (D. R.); Firth of Clyde; Salcombe, Devon; Westport Bay, and Valentia, Ireland; Seaton Sluice, Northumberland, between tide-marks (A. M. N.) Irish Channel and Belfast Lough (Malcomson).

Distribution.—Fosse de Cap Breton, Bay of Biscay, 30–60 fath. (A. M. N.); rivers Maas and Scheldt (G. S. B.).

19. *Cytherura clathrata*, G. O. Sars.

1868. *Cytherura clathrata*, Brady, Mon. rec. Brit. Ostrac., p. 446, pl. xxix., figs. 43–46.
1874. *Cytherura clathrata*, Brady, Crosskey, and Robertson, Mon. Post-tert. Entom., p. 201, pl. xi., figs. 1–4.

Additional localities.—Boness, Firth of Forth; coasts of Durham, Northumberland, and North Yorkshire; between tide-marks at Whitley and Seaton Sluice, Northumberland; river Ouse, at Lynn (G. S. B. and D. R.); ten miles E. of Balta, Shetland, in 72 fath.; the Minch (A.M.N.); Irish Channel; Belfast Lough; and Island Magee, N.E. Ireland (Malcomson).

Distribution.—Lofoten Islands, 6–12 fath. (G. O. Sars); "Valorous" Expedition, Stat. 3, Davis Strait, lat. 69° 31′ N., long. 56° 1′ W., 100 fath. (A. M. N.); Deevie Bay and Ginevra Bay, Spitzbergen, Mr. Lamont; off Cape Victoria, Bache Island, Capt. Feilden in Nares' Expedition; Hunde Islands, Baffin's Bay, 60–70 fath., Dr. Sutherland's dredgings; Hammerfest Harbour (G. S. B.).

Fossil.—Scotland, England (Bridlington), Ireland (Portrush), Norway.

20. *Cytherura cellulosa*, Norman.

(Synonym: *Cytherura nana*, G. O. Sars.)

1868. *Cytherura cellulosa*, Brady, Mon. rec. Brit. Ostrac., p. 446, pl. xxix., figs. 47–50, 60.
1874. *Cytherura cellulosa*, Brady, Crosskey, and Robertson, Mon. Post-tert. Entom., p. 200, pl. xi., figs. 5, 6.

A common and very distinct little species, almost ubiquitous round the British coasts, between tide-marks and in moderate depths of water, and commonly reaching up into the mouths of rivers.

Distribution.—Christiania Fiord (G. O. Sars); Batalden near Floro, off Sartoro Bergen Fiord, Kors Fiord, Stoksund 120 fath.—all in Norway (A. M. N.); river Scheldt, near Antwerp (G. S. B.); Fosse de Cap Breton, Bay of Biscay, 180–200 fath.; Bay of Naples (A. M. N.).

Fossil.—Scotland, England, Wales, Ireland.

Genus X.—Cytheropteron, G. O. Sars.

[Type, *Cytheropteron latissimum* (Norman).]

1. *Cytheropteron latissimum* (Norman).

Synonym: *Cytheropteron convexum*, G. O. Sars (*non Cythere convexa*, Baird).

1868. *Cytheropteron latissimum*, Brady, Mon. rec. Brit. Ostrac., p. 448, pl. xxxiv., figs. 26–30.

1874. *Cytheropteron latissimum*, Brady, Crosskey, and Robertson, Mon. Post-tert. Entom., p. 202, pl. viii., figs. 19–23.

1878. *Cytheropteron latissimum*, Brady, Ostracoda, Antwerp Crag., Trans. Zool. Soc., vol. x., p. 403, pl. lxix., figs. 1 *a–d*.

This species is found pretty plentifully on many parts of the British coasts, from low-water mark downwards, very rarely between tide-marks. It is most abundant and of finest growth on the northern and eastern coasts, dying out apparently towards the south. We have no record of its occurrence in the Mediterranean or Bay of Biscay, and it is extremely rare on the southern and western coasts of England and Ireland, though common in the west of Scotland. It was not found in any of the "Challenger" dredgings either from the Atlantic or elsewhere, but it occurs in material brought from the Arctic regions. The Scilly Island habitat noted elsewhere (Brady and Robertson, on Ostracoda taken among the Scilly Isles, Ann. and Mag. Nat. Hist., ser. IV., vol. xiii. (1874), p. 115) seems to be an error.

Distribution.—Christiania Fiord, and thence to Finmark (G. O. Sars); Lervig Bay, Norway, 3–25 fath. (A. M. N.); Iceland; river Scheldt, Holland; Spitzbergen and Baffin's Bay (G. S. B.).

Fossil.—Scotland, England (Bridlington), Norway, Canada.

2. *Cytheropteron nodosum*, Brady.

1868. *Cytheropteron nodosum*, Brady, Mon. rec. Brit. Ostrac., p. 448, pl. xxxiv., figs. 31–34.
1874. *Cytheropteron nodosum*, Brady, Crosskey, and Robertson, Mon. Post-tert. Entom., p. 203, pl. viii., figs. 12–15.

Additional localities.—Shetland; Firths of Clyde and Forth; Montrose Basin; river Wansbeck, Northumberland; off coasts of Durham and North Yorkshire; off Lantern Hill, Ilfracombe, and Eddystone Lighthouse; Dungeness Bay; Scilly Isles (G. S. B. and D. R.); off Tarbert, Loch Fyne, 25 fath.; Dogger Bank; Salcombe, Devonshire (A. M. N.).

Distribution.—Off Sartoro, Bergen Fiord, 15–40 fath.; Lervig Bay, 3–25 fath.; Hardanger Fiord, off Stordöen, 50–100 fath.; Fosse de Cap Breton, Bay of Biscay, 180–200 fath. (A. M. N.); Gulf of St. Lawrence (G. S. B. and D. R.).

Fossil.—Scotland, England, Ireland, Canada, and Norway.

3. *Cytheropteron pyramidale*, Brady.

(Plate xx., figs. 1–3.)

1868. *Cytheropteron pyramidale*, Brady, Ann. and Mag. Nat. Hist., ser. iv., vol. ii., p. 34, pl. v., figs. 11–14.

Shell tumid, subpyramidal; seen from the side, subrhomboidal, highest in the middle; greatest height equal to more than half the length; anterior extremity obliquely rounded, posterior narrowed and produced in the middle; superior margin very strongly arched, highest in the middle, and sloping steeply towards each extremity; inferior slightly convex, sinuated in front and bending upwards behind. Outline, as seen from above, obovate, widest about the middle, suddenly and sharply acuminate in front, broadly mucronate behind; width and height about equal. End view triangular, sides very slightly convex. Shell-surface marked with conspicuous fossæ, which are arranged in transverse curved rows; ventral surface sculptured with interrupted longitudinal furrows. Length, ·54 mm.

This species partakes of the characters of *C. latissimun* and *C. punctatum;* but from the first-named species differs in the proportions and shape of the shell, and from the latter in the style of surface-sculpture.

Distribution.—The type specimens were dredged by Messrs. Robertson and Crosskey, in 25–30 fath., muddy bottom at Dröbak, Christiania Fiord. Davis Strait, lat. 69° 31′ N., long. 56° 1′ W., 100 fath., "Valorous," 1875 (A. M. N.);

Lincoln's Bay, Grinnell Sound 82° 8′ N., Tyndall Glacier 27 fath., off Cape Frazer 50 and 80 fath., Captain Feilden in Nares' Arctic Expedition; Deevie and Ginevra Bays, Spitzbergen, Mr. Lamont (G. S. B.).

The specimens taken off the Lantern Hill, Ilfracombe, and referred to this species, we now look upon as belonging to *C. nodosum.*

4. *Cytheropteron inflatum*, Brady, Crosskey, and Robertson.

(Plate xx., figs 19–21.)

1868. *Cytheropteron inflatum* (B., C., and R.), Brady, Contrib. to Study of Entomostraca, Ann. and Mag. Nat. Hist., ser. IV., vol. ii., p. 33, pl. v., figs. 8–10.

1874. *Cytheropteron inflatum*, Brady, Crosskey, and Robertson, Post-tertiary Entom., p. 204, pl. viii., figs. 24–27; pl. xiv., figs. 26–29.

Shell, seen laterally, subrhomboidal or subtriangular, greatest height in the middle, and equal to two-thirds of the length; anterior extremity rounded, posterior produced into a wide, obtuse, median beak; superior margin very strongly arched, gibbous, highest in the middle; inferior convex in the middle in the situation of the lateral ala. Seen from above, the outline is broadly ovate, with equally tapering and sharply mucronate extremities; greatest width situated in the middle, and equal to more than half the length. End view almost quadrate, scarcely at all tapered at the apex. Surface of the shell minutely and closely punctate; longitudinally striated on the ventral surface, alæform processes evenly and boldly rounded, and but slightly prominent. Length, ·65 mm.

British Habitat.—Loch Fyne (A. M. N.).

Distribution.—Stoksund, near mouth of Hardanger Fiord, 126 fath., Norway (A. M. N.); Ginevra Bay, Spitzbergen, Mr. Lamont; Cumberland Inlet, Baffin's Bay, $15\frac{1}{2}$ fath.; and North Atlantic (G. S. B. and D. R.).

Fossil.—Scotland, Canada.

5. *Cytheropteron subcircinatum*, G. O. Sars.

(Plate xx., figs. 26–28.)

1865. *Cytheropteron subcircinatum*, G. O. Sars, Oversigt af Norges marine Ostracoder, p. 81.

Shell, seen from the side, subovate, greatest height central, more than half the length; anterior extremity rather narrowly rounded, greatest projection nearly central; posterior extremity slightly produced into a short central beak, which is broadly truncate at the end; dorsal margin very boldly arched, anterior and posterior declination of nearly equal length; ventral margin slightly concave in front,

then overhung by the convexity of the lateral protuberance, behind which it slopes upwards to the hinder extremity. Seen from above, the form is very broadly oval, breadth greater than the height, and in Sars' type-specimen equal to two-thirds of the length (in ours to somewhat less), broadly pointed in front, mucronate behind. Valves having the lateral protuberance extending along the greater part of the length, its greatest convexity central, thence towards both ends gradually sloping away into the body of the valve without angularity; surface pitted with small round foveolæ. Length, ·50 mm.

This is not *C. subcircinatum*, Brady, Mon., which is the *C. depressum* of this Paper. (See p. 218.)

Our Norwegian examples have been identified by Professor Sars, who has also kindly sent to us a drawing of the type-specimen.

C. subcircinatum approaches to *C. latissimum* (Norman), from which, however, as Sars pointed out in his description, it may at once be distinguished, "protuberantiâ laterali fere semicirculariter arcuatâ, minimeque angulatâ."

Habitat.—Christiania Fiord, Norway, very rare (G. O. Sars); Lervig Bay, Stordoen, Norway, 2–10 fath. (A. M. N.).

6. *Cytheropteron læve*, n. sp.

(Plate xx., figs. 29–31.)

Shell, seen from the side, nearly ovate, greatest height in front of the middle, equal to two-thirds of the length; anterior extremity remarkably broadly, and evenly rounded throughout; posterior extremity much narrower, the dorsal slope anterior to it being long, evenly rounded; dorsal margin evenly arched (the central portion in one of the valves slightly flattened), anterior slope very slight and gradual, posterior much steeper; ventral margin straight. The greatest tumidity is, as usual in the genus, on the ventral portion of the posterior half, but this tumidity is only effected by the gentle rising of the shell on all sides, and it as well as all parts of the surface is smooth and devoid of sculpture. Seen from above, the greatest tumidity is at about one-fourth the length from the posterior extremity, behind which the sides rapidly and without convexity converge, while forwards the approach to each other is gradual for some distance, until an angularity is formed by their more rapid convergence to the anterior extremity, which is narrower than the posterior. Length, ·6 mm.

Two single valves, dredged by H. M. S. "Porcupine," Stat. 41, 1869, lat. 49° 4′ N., long. 12° 22′ W., in 584 fath. (A. M. N.).

7. *Cytheropteron punctatum*, Brady.

Synonym: *Cytheropteron tricorne*, Brady (*non C. tricorne*, Bornemann).

1868. *Cytheropteron punctatum*, Brady, Mon. rec. Brit. Ostrac., p. 449, pl. xxxiv., figs. 45–48.

Additional localities.—Off Farland Point Cumbrae, amongst shell debris in 19 fath.; Lochgoil, 30 fath.; off Girvan, 12–15 fath., and other places in the Firth of Clyde; Westport and Roundstone Bays, Ireland; off Penarth Head, and Mumbles, South Wales (G. S. B. and D. R.); Shetland, 10 miles east of Island of Balta, 75 fath.; off Tarbert, Loch Fyne, 25 fath. (A. M. N.); Belfast Lough (Dr. Malcomson).

Distribution.—Off Sartoro, Bergen Fiord, Norway, 15–40 fath; Fosse de Cap Breton, Bay of Biscay, 180–200 fath. (A. M. N.).

8. *Cytheropteron intermedium*, G. S. Brady.

1878. *Cyteropteron intermedium*, Brady, Ostracoda Antwerp Crag, Trans. Zool. Soc., vol. x., p. 403, pl. lxix., figs. 3 *a–c*.

1880. *Cytheropteron intermedium*, Brady, Report "Challenger" Ostracoda, p. 137, pl. xxxiv., figs. 1 *a–d*.

Shell elongated. Seen from the side, flexuous, subrhomboidal, depressed in front, highest near the middle, height equal to more than half the length; anterior extremity obliquely rounded; posterior produced above the middle into a small, slender beak, below which it sweeps downwards with an oblique gentle curve; dorsal margin moderately arched; ventral sinuated in front, convex behind the middle. Seen from above, the outline is hastate, widest behind the middle where the lateral alæ project outwards at an obtuse angle; from this point the lateral margins converge in a gentle curve towards the front, terminating in a produced subacuminate extremity; backwards the sides converge from the extremities of the alæ at first almost rectangularly, then more gradually to form the posterior extremity, which, like the anterior, is subacute. End view equilaterally triangular, rounded at the apex; lateral angles produced and truncated; sides gently obtusely convex. Shell almost smooth; ventral surface slightly nodulated and irregular. Length, ·5 mm.

Distribution.—Vigo Bay, Spain, 11 fath., "Challenger" Expedition (G. S. B.).

Fossil.—Crag; Antwerp (G. S. B.).

9. *Cytheropteron crassipinnatum*, n. sp.

(Plate xx., figs. 16–18.)

Shell, seen from the side, subovate, highest in the middle, greatest height equal to two-thirds of the length; anterior extremity not broad, obliquely rounded, greatest projection below the middle; hinder extremity produced into a well-developed, blunt beak; dorsal margin boldly arched, posterior declination longer than the anterior; ventral margin slightly concave in front, then convex—the convexity chiefly occasioned by the outline of part of the overhanging ala—behind the margin slopes gradually upwards to form the beak. Seen from above, the form is in front broadly triangular, the central portion of the base of the triangle produced behind into a very large central mucro formed by that portion of the shell which is behind the alæ, lateral angles almost rectangular but furnished with a minute triangular outwardly-directed point, the sides tapering, with slight convexity at first, to the rather blunt anterior extremity; greatest width equal to about four-fifths of the length. Valves solid, their surface sculptured with irregular cells, the alæ very solid and blunt at the edge; on a line with and above the point whence the ala springs behind there is a slight protuberance on the side of the shell. Length, ·40 mm.

In outline this species, whether seen dorsally or laterally, is very like the young of *C. alatum*, but may be distinguished from it by the solidity and bluntness of the edge of the alæ, and by the surface sculpture. The same characters distinguish it from *C. hamatum*, and well-marked differences in the dorsal aspects separate it from the last-named species, and also from *C. punctatum*, to which latter species it approaches in the substantial character of the ala.

Dredged fifteen miles off Valentia, Ireland, in 1870 (A. M. N.).

10. *Cytheropteron hamatum*, G. O. Sars.

(Plate xx., figs. 13–15.)

1868. *Cytheropteron vespertilio*, Brady, Ann. and Mag. Nat Hist., ser iv., vol. ii., p. 33, pl. v., figs. 6, 7 (*non Cypridina vespertilio*, Reuss).

1869. *Cytheropteron hamatum*, G. O. Sars, Nye Dybvandscrustaceer fra Lofoten. Vidensk-Selsk Forhand, p. 172.

Shell of female, seen from the side, shortly subovate, highest in the middle, height equal to more than half the length; anterior extremity obliquely rounded,

most prominent below the middle; posterior extremity somewhat produced, forming a short beak, which inclines upwards; dorsal margin boldly arched, anterior declination much steeper than posterior; ventral margin slightly sinuated in front, afterwards convex; lateral ala well developed, its edge acute, behind forming a right angle with the shell, and furnished at its tip with an acute spine, which is directed outwards, and generally curved forwards at its extremity. Seen from above, very wide, the proportionate width in front being greater than in allied species, nearly the greatest breadth is thus attained before the middle of the shell, and thence the outline is continued with scarcely any additional expansion to the alæ; behind the alæ the valves are suddenly contracted; both extremities are acuminate, and the angle formed by the junction of the valves nearly equal; greatest diameter equal to more than half the length. Surface of valves finely punctate or pitted; anterior extremity, in living examples, very finely toothed. Length, ·70 mm.

The *Cypridina vespertilio*, Reuss, to which Dr. Brady first referred this species is scarcely this form, the hind margin of the alæ showing remnants of teeth-like points, such as are only known to us among recent species in *C. alatum*, which, when actual comparison has been made, may prove to be Reuss's species.

Distribution.—Lofoten Islands, 120–300 fath. (G. O. Sars); Stoksund, Hardanger Fiord, Norway, 80–100 fath. (A. M. N.); Ginevra Bay, Spitzbergen, Mr. Lamont; Cumberland Inlet, Davis Strait, lat. 66° 10′ N., long. 65° 15′ W., 15 fath. (G. S. B.)

Fossil.—Scotland (Dryleys and Elie).

11. *Cyheropteron arcuatum*, Brady, Crosskey, and Robertson.

(Plate, xx., figs. 28–30).

1874. *Cytheropteron arcuatum*, Brady, Crosskey and Robertson, Mon. Post-tert. Entom., p. 203, pl. viii., figs. 16–18; and pl. xiv., figs. 19–22.

Shell seen laterally very broadly subovate or subelliptical, highest in the middle, height equal to nearly three-fourths of the length, broadly and evenly rounded in front, behind produced very narrow, and scarcely rounded; dorsal margin forming an extremely bold arch, sloping gently towards the front, and very steeply behind; ventral sinuated in front of the middle, and upcurved behind. Seen from above, the outline is arrow-headed or subhexagonal, width equal to two-thirds of the length, the lateral margins, or alæ, in the middle of their course, almost straight and parallel, the straight portions forming in front an obtuse angle at the point where they converge in nearly straight lines to the acute anterior extremity, ending behind in a rectangular truncation, from which projects in the middle the large

triangular posterior termination of the shell. End view triangular, equilateral, the ventral line prominent in the middle, the upper angle tapering, acute, and somewhat twisted. The valves are irregularly waved and sulcate in a transverse direction, and just within the middle third of the ventral portion is a well developed ala with rounded margin and rectangular posterior extremity. Length, ·44 mm.

Habitat.—Dredged in 80 fath., Cape Frazer; Baffin's Bay. This species is more like *C. hamatum*, Sars., than any other, but differs in its very strongly arched outline, and in its rounder, wider, and less produced extremities. In the few recent specimens which we have seen, the lateral alæ are obtusely rounded, and have no spine whatever; but in fossil specimens there is frequently a terminal spine.

Fossil.—Scotland and Ireland, post-tertiary.

12. *Cytheropteron alatum*, G. O. Sars.

(Plate xx., figs. 8–10.)

1865. *Cytheropteron alatum*, G. O. Sars, Oversigt af Norges marine Ostracoder, p. 81.
1868. *Cytheropteron alatum*, Norman, Last Report Dredging among the Shetland Isles, Brit. Assoc. Report, p. 294.
1872. *Cytheropteron alatum*, Brady, Ann. and Mag. Nat. Hist., ser. iv., vol. ix., p. 60, pl. ii., figs. 4–6.
1872. *Cytheropteron inornatum*, idem ibidem, p. 61, pl. ii., figs. 1–3.

Shell, seen from the side, long ovate, with very large and acutely-pointed lateral alæ, greatest height central, equal (exclusive of ala projection) to rather more than half the length; all the margins of the shell are very acute; anterior extremity well and evenly rounded; posterior extremity produced centrally into a very large rostrate process, obliquely truncate at the extremity; dorsal margin very boldly arched; ventral sinuated in front of the middle, well arcuated behind; lateral ala seen prominently projected over the ventral margin, this alar process is of very large size, with sharply acute edges, terminating outwardly in a sharp point, and having the straight hinder margin edged with a series of about ten flattened plates, of which the two innermost are usually larger than the rest. Seen from above, the form presented is a very wide, acutely-angled triangle, the sides of which are only very slightly convex, while the base consists of the dentated hinder edges of the alæ, between which the rostrate posterior portion of the shell is projected (beyond the base of the triangle described) as a very acute triangular median process; width between the apices of the lateral alæ greater than the length. End view triangular, base greatly exceeding the height, sides slightly concave, basal angles (ends of alæ) excessively produced and acute. Surface of valves white, pellucid, smooth or finely punctate. Length, ·70 mm.

Half-grown examples differ considerably from the adult, and might easily be confused with other species. This condition was described by Dr. Brady under the name *C. inornatum*; the shell is higher in proportion to its length, the alæ much less developed, and their hinder margin devoid of the flattened teeth. From *C. punctatum* it is distinguished by the more delicate structure of the shell, the acute margins, large alæ, more produced beak, and smoother surface. See also remarks under *C. crassipinnatum.*

Habitat.—Shetland, 5–8 miles east of the Island of Balta, in 40–50 fath.; off Tarbert, Loch Fyne, 25 fath.; off Valentia, Ireland, 112 fath. (A. M. N.) In the Clyde district it has occurred in Kilchattan, Fintry, and Rothesay Bays, Loch Striven, and near Ardrossan (G. S. B. and D. R.).

Distribution.—Christiania Fiord, Norway in 20–30 faths. (G. O. Sars!)

13. *Cytheropteron mucronalatum*, Brady.

1880. *Cytheropteron mucronalatum*, Brady, Report "Challenger" Ostracoda, p. 140, pl. xxxii., figs. 8 *a–d*.

Shell, seen from the side, broadly subovate, or nearly semicircular; height equal to more than two-thirds of the length; anterior extremity broadly rounded, and bearing a few strong but short and blunt spines; posterior narrower, also rounded and furnished with a few spines, which are more acute than those of the front margin; dorsal margin very boldly arched, the arch continued down both ends of the shell to the ventral margin, but the hinder slope is longer than the anterior; ventral gently convex. Seen from above, the outline is ovate, widest in the middle, width equal to more than half the length, but not equal to the height; sides converging gradually towards the front, but more rapidly behind, both extremities running out in obtusely mucronate form, with equal terminations. End view an acute-angled triangle, the angles all well pronounced, sides longer than the base, and very slightly convex; base indented in the middle. Valves white, pellucid, or even transparent and glassy, smooth; close within, and overhanging and concealing the ventral margin runs a much elevated crest, commencing (which is unusual in the genus) at the anterior extremity of the shell, crowned by two linear riblets, and gradually rising higher until it nearly reaches the hinder extremity, where it abruptly terminates, and bears just before the termination a single, strong, but not very long spine; the valves attain their greatest tumidity at this crest, and more especially on the hinder part of the shell, whence they rapidly converge, like the sides of a high-pitched roof, to the dorsum, where their junction is very acute; ventral surface almost flat, but having a central longitudinal depression. The right

and left valves are remarkably different in size and shape, the dorsal margin of the right being abruptly truncated, and forming a perfectly straight line, very much below the level of the valve of the left side, which is very boldly rounded. Length, 1·3 mm.

Dredged by the "Challenger," near the Azores, Stat. 70., lat. 38° 25′ N., long. 35° 50′ W., 1650 fath. (G. S. B.); and by the "Valorous" Expedition, 1875, in the North Atlantic, Stat. 15, lat. 55° 58′ N., long. 28° 42′ W., 1485 fath.; and Stat. 16, lat. 55° 10′ N., long. 25° 58′ W., 1785 fath. (A. M. N.).

In the Pacific it was dredged by the "Challenger" in from 1450 to 2050 fath., at five stations, ranging from off Japan to near the coast of Patagonia. This remarkably fine species has thus probably a world-wide distribution in extreme depths of the oceans.

14. *Cytheropteron montrosiense*, Brady, Crosskey, and Robertson.

(Plate xix., figs. 25, 26.)

1866. *Cythere rhomboidea*, Brady, New and imperfectly-known Ostracoda, Trans. Zool. Soc. Lond., vol. v., p. 381, pl. lxii., figs. 5 *a–b* (*non C. rhomboidea*, S. Fischer, 1854).

1868. *Cytheropteron montrosiense* (B., C., & R.), Brady, Ann. and Mag. Nat. Hist., ser. iv., vol. ii., p. 33, pl. v., figs. 1–5 (figured, but not described).

1874. *Cytheropteron montrosiense*, Brady, Crosskey, and Robertson, Mon. Post.-tert. Entom., p. 204, pl. viii., figs. 28–36; and pl. xiv., figs. 13–16.

Shell of *female* (?), as seen from the side, subrhomboidal, nearly equal in height throughout, height equal to more than half the length; anterior margin broadly rounded; posterior obliquely truncate below, produced above into a broad projection or beak; dorsal margin slightly convex, sinuated, or in old specimens deeply sulcate behind just before its junction with the flattened beak; ventral margin straight in front, convex behind. Outline, as seen from above, rhomboidal, suddenly widened behind the middle; extremities pointed, the posterior strongly mucronate. End-view broadly triangular, the sides very convex; the base flat, and expanded at the sides. Surface of valves with the lateral protuberance or ala very prominent, but short, forming a large irregularly rounded projection behind the middle of the ventral margin, lateral surface pitted with large polygonal excavations, ventral surface longitudinally rugose. Shell of the *male* (?) higher in front, the dorsal margin sloping steeply backwards, lateral and posterior protuberances poorly developed; surface markings smaller. Length, ·55 mm.

British locality.—Roundstone Bay, Ireland (G. S. B. and D. R.).

Distribution.—Cumberland Inlet, in Baffin's Bay, 15 fath., lat. 66° 10′ N., long. 67° 15′ W. (G. S. B. and D. R.); Ginevra Bay, Spitzbergen, Mr. Lamont, lat. 82° 27′ N., 6 fath.; Atlantic Ocean, 45 fathoms, Commander Dayman (G. S. B.).

Fossil.—Scotland, England (Hopton Cliff), Ireland (Woodburn), Norway.

The young of this species is described by the authors of the "Post-tertiary Entomostraca," as having the valves glabrous, and devoid of all trace of pitted sculpture.

15. *Cytheropteron angulatum*, Brady and Robertson.

(Plate XIX., figs. 17, 18.)

1872. *Cytheropteron angulatum*, Brady and Robertson, Ann. and Mag. Nat. Hist., ser. IV., vol. ix., p. 62, pl. ii., figs. 7, 8.

1874. *Cytheropteron angulatum*, Brady, Crosskey, and Robertson, Mon. Post-tert. Entom., p. 206, pl. viii., figs. 37–40.

Shell of *female*, viewed laterally, subrhomboidal, flexuous, bending slightly downwards in front, and twisted much upwards behind, greatest height central, equal to half or more than half the length; anterior extremity broadly rounded; posterior without any infero-posteal angle, in that part sloping obliquely and convexly backwards, and upwards, until at the supero-posteal angle a little upward-bent lobe is produced; dorsal margin boldly arched; anteriorly the sweep is continued right round until the ventral margin is reached; posteriorly there is a very slight concavity in front of the pointed corner, where it joins the posterior margin; ventral margin straight or very gently convex in the middle, where, however, it is hidden by the projection of the ala, the anterior portion convex, the posterior arcuately sloping upwards. Seen from above, subpentagonal, somewhat boat-shaped, widest in front of the middle; sides in front of this rapidly converging at an angle of fully 75°; behind the outline consists of a series of sinuations, the posterior extremity very wide, the corners jutting outwards, and termination flexuous; the greatest width is a little less than the height. Surface of valves flattened, and, except at the alæ, exceedingly rugged, the lateral ala not much elevated, but having at some little distance within, and parallel to the margin, a strongly-marked longitudinal ridge, below which is a groove, which is deepest behind, and is crossed in front by a transverse bar which sometimes takes a nodulous form; above the ridge several irregularly flexuous ribs stretch transversely across the valves to the dorsal margin, coalescing here and there into large rounded eminences, and having in their interspaces numerous, irregularly angulated depressions; at the posterior extremity there is an elevated and lappet-like projection, having a curve upwards, and it is the presence of this lappet, which mainly contributes to the very unusual aspect of this species. In two or three specimens (? *males*) the lappet is absent, the appearance of the shell being thus considerably altered. Length, ·40 mm.

British localities.—Rosneath and Kilchattan Bay, 45–56 fath., Firth of Clyde; Roundstone Bay, Ireland (G. S. B. and D. R.); Loch Fyne, off Tarbert, 25 fath. (A. M. N.).

Fossil.—Scotland, England (Bridlington), Canada.

From its abundance in the glacial clays of Scotland it may be expected that this species will hereafter prove to be a recent Arctic form.

16. *Cytheropteron depressum*, n. sp.

(Plate xx., figs. 22, 23.)

1868. *Cytheropteron subcircinatum*, Brady, Mon. rec. Brit. Ostrac., p. 447, pl. xxxiv., figs. 39–42 (but not *C. subcircinatum*, G. O. Sars, for which see p. 209).

The description of this species in the "Monograph," should be regarded as inaccurate, as it was drawn up from Sars' description of the true *C. subcircinatum*, in conjunction with the examination of the single British specimen then known of the present species. In the Plate, what was regarded as the posterior extremity is really the anterior.

Shell, seen from the side, subovate, greatest height equal to more than half the length, and situated at the commencement of the posterior dorsal slope, the ventral surface is remarkably broad and flat, the valves being projected directly outwards and forming a sharp angle at the junction of the ventral and lateral margins, anteriorly the true narrowly rounded margin is seen lying below and a little in advance of the commencement of the gibbosity; posterior extremity wider than the anterior, rounded, its greatest projection central; dorsal margin flattened in its central portion, posterior declination longer than the anterior; ventral margin formed by two arcuations, the anterior of which occupies more than two-thirds of the length, and is formed by the keeled edge of the protuberance, the posterior commences at the point where the edge of the protuberance passes upwards, and is formed by the true margin of the lips. The outline of the shell, seen dorsally, is a broad oval, with boldly arched sides, greatest breadth exceeding the height, and equal to more than two-thirds of the length; extremities broad, the anterior slightly the wider; from each valve, at its extremities, is projected a little microscopic point. Valves glassy, subhyaline, with scattered opaque white specks. Length, ·35 mm.

Habitat.—Off North Yorkshire; Scilly Islands; off Eddystone Lighthouse; Westport, Clifden, Roundstone, and Galway Bays, and Lough Swilly, Ireland (G. S. B. and D. R.); Dartmouth Harbour; Valentia, Ireland (A. M. N.); Irish Channel and Belfast Lough (Malcomson).

Distribution.—Rivers Scheldt and Maas, Holland (G. S. B.).

17. *Cytheropteron testudo*, G. O. Sars.

(Plate XXI., figs. 1, 2.)

1869. *Cytheropteron testudo*, G. O. Sars, Nye Dybvandscrustaceer fra Lofoten, Vidensk-Selsk. Forhand, p. 29.

Shell, seen from the side, ovate, with a rostrate projection behind; valves unequal, the right higher and more strongly arched than the left; greatest height central much more than half the length, ventrally extremely broad and almost flat; from the basal edge the sides rapidly converge in a roof-like manner, so that dorsally they are narrow and keeled at their junction; anterior margin most prominent below, thence sweeping with a continuous and almost semicircular curve round the dorsal margin to the posterior extremity, where the dorsal and ventral margins continued evenly backwards form a central narrow, sharp-pointed, horizontally directed beak; ventral margin itself hidden by the very acute edge of the lateral protuberance, which is projected outwards, and presents an evenly convex outline. Seen from above, very broadly oval, the greatest breadth central, much greater than the height, and equal to two-thirds of the entire length; sides boldly and evenly arched; front rounded, and remarkably obtuse, though not truncate (the valves meeting at an angle of fully 150 degrees); behind the beak forms, beyond the oval, a mucronate projection, which has a narrowly truncate termination. Valves thin, pellucid, white, growing opaque and milky with age; surface wholly devoid of rugæ, but covered with closely-set minute impressed punctations, and bearing also a few scattered circular papillæ; ventral surface marked with rather faint longitudinal ribs. Length, ·5 mm.

Distribution.—Very rare in 120 fath., Lofoten Islands (G. O. Sars); in two places in the Hardanger Fiord, namely, off Stordöen, in 210 fath., and in Stoksund, 126 fath., and also off Batalden near Floro, Norway (A. M. N.).

18. *Cytheropteron humile*, n. sp.

(Plate XX., figs. 4–7.)

Shell extremely depressed; seen from the side, the height is nearly the same throughout and equal to only one-third of the length; the extremities are obliquely subtruncated, sloping very steeply from above, and only slightly rounded; superior margin straight, with a very slight sinuation in the middle; inferior also straight or but very slightly arcuate. Seen dorsally, the shape is broadly ovate,

with obscurely pointed, nearly equal extremities; the greatest width, situated in the middle, is equal to more than two-thirds of the length, and twice the height; the ventral surface is almost perfectly flat, very faintly upturned at the ends, and almost imperceptibly hollowed in the middle. Shell-surface finely and closely punctate, and bearing also numerous rather large, flattened, circular papillæ; the ventral surface has a few faint longitudinal lines in the centre, and round the edges only bears a series of hair-like papillæ. Length, ·33 mm.

Several examples of this very distinct and interesting but minute species were dredged in the Clyde, off Fort Matilda, Greenock, by Mr. Thomas Scott of that place, to whose kindness we are indebted for the opportunity of describing it. More recently we have received specimens from the Marquis de Folin, dredged off Vigo (G. S. B.).

A most remarkable little species, on account of the excessive width as compared with the height.

Genus XI.—Bythocythere, G. O. Sars.

[Type, *Bythocythere turgida*, G. O. Sars.]

1. *Bythocythere constricta*, G. O. Sars.

1868. *Bythocythere constricta*, Brady, Mon. rec. Brit. Ostrac., p. 451, pl. xxxv., figs. 47–52.

1874. *Bythocythere constricta*, Brady, Crosskey, and Robertson, Mon. Post-tert. Entom., p. 208, pl. xvi., figs. 9, 10.

1878. *Bythocythere constricta*, Brady, Ostracoda Antwerp Crag, Trans. Zool. Soc., vol. x., p. 405.

Additional localities.—Off north coast of Scotland; off Roseneath and other places in the Firth of Clyde; Loch Long and Loch Fyne; coasts of Durham and North Yorkshire, 20–35 fath.; off Lantern Hill, Ilfracombe; off the Eddystone and Mumbles, South Wales; Scilly Islands; Loughs Mulroy and Swilly, and Dublin Bay, Ireland (G. S. B. and D. R.); thirty miles off Aberdeen; Scarborough, tide-marks; off Valentia, Ireland (A. M. N.); Irish Channel and Belfast Lough (Malcomson).

Distribution.—A single specimen, 20–30 fath., Christiania Fiord, Norway (G. O. Sars); off Sartoro, Bergen Fiord, 15–40 fath., and Kors Fiord, 180 fath., Norway; Fosse de Cap Breton, Bay of Biscay, 30–60 fath. (A. M. N.); Deevie Bay; Spitzbergen, Mr. Lamont (G. S. B.).

Fossil.—Crag; Antwerp. Post-tertiary; Scotland.

2. *Bythocythere turgida*, G. O. Sars.

1868. *Bythocythere turgida*, Brady, Mon. rec. Brit. Ostrac., p. 452, pl. xxxiv., figs. 35-38.
1870. *Bythocythere turgida*, Brady, Nat. Hist. Trans. Northumberland and Durham, vol. iii., p. 372, pl. xiii., figs. 1-4.

Additional localities.—Off Eddystone Lighthouse; Kilchattan, Roseneath and Rothesay Bays, Firth of Clyde; off Durham and North Yorkshire, 20–45 fath.; among the Scilly Islands; Roundstone Bay, Ireland (G. S. B. and D.R.); St. Magnus Bay, and off the Island of Balta, Shetland, 50–73 fath.; off Valentia, Ireland (A. M. N.); Irish Channel and Belfast Lough (Malcomson).

Distribution.—Hollingspollen, near Dröbak, Norway, 10–12 fath. (G. O. Sars); Spitzbergen (?), Mr. Lamont; Gulf of St. Lawrence, Mr. G. M. Dawson (G. S. B.).

3. *Bythocythere insignis*, G. O. Sars.

(Plate XXIII., figs. 1, 2.)

1869. *Bythocythere insignis*, G. O. Sars, Nye Dybvandscrustaceer fra Lofoten (Vidensk-Selsk. Forhand, p. 173).

Shell of male irregularly rugose and impressed, having two large nearly rectangular lateral protuberances interrupted in the middle by a transverse furrow, and behind irregularly crenulated. Seen from the side, the form is elongated subrhomboidal, the greatest height scarcely equalling half the length; dorsal margin nearly straight; ventral sinuated in the middle; anterior extremity obtusely rounded; posterior obliquely truncate or exserted into an obtuse process, which is continuous with the dorsal margin. Seen from above, subrhomboidal, greatest width situated behind the middle, and more than half the length; width gradually decreasing in front, suddenly behind; both extremities acuminate. Valves thin and pellucid, sparingly furnished with short hairs. No eyes. Antennules very slender, consisting of seven joints as in the other species, the last of moderate length, slightly shorter than the preceding. Terminal portion of the copulatory organs irregularly triangular, furnished with a single, short, apical seta. Length, 0·76 mm.

Habitat.—Very rare in 120 fath., Lofoten Islands (G. O. Sars).

Our figures are taken from a drawing kindly sent to us by the author.

4. *Bythocythere bicristata*, n. sp.

(Plate xix., figs 15, 16.)

The shell, seen laterally, is obliquely subquadrate, not much higher in front than behind, the greatest height equalling about two-thirds of the length; anterior extremity oblique, moderately well rounded; posterior subangular above, and much rounded off below; dorsal margin slightly gibbous at the anterior third and sloping rather steeply in front, almost straight behind; inferior slightly convex. Seen from above, the outline is doubly triangular, the anterior two-thirds forming a large triangle, from the posterior border of which projects a smaller one; the extremities obtuse, and the two large lateral protuberances rounded. End view subquadrangular, the base very wide, convex, with sharply produced lateral angles, the apex much narrower, and rounded at the angles; lateral margins slightly concave. The surface of the shell is smooth, or nearly so; the lateral aspect of each valve marked by a deep transverse median furrow, and dilated just within the ventral margin, so as to form a prominent longitudinal ridge, which ends in an abruptly rounded angle at the posterior third. Length, ·65 mm.

This is a well-marked and very distinct species, the only examples of which were dredged in the Unst Haaf, Shetland (A. M. N.).

5. *Bythocythere recta* (Brady).

(Plate xix., figs. 13, 14.)

1868. *Cytheropteron rectum*, Brady, Mon. rec. Brit. Ostrac., p. 476.

1869. *Cytheropteron rectum*, Brady and Robertson, Dredging West Ireland, Ann. and Mag. Nat. Hist., ser. iv., vol. iii., p. 372, pl. xx., figs. 6–8.

1874. *Cytheropteron rectum*, Brady, Crosskey, and Robertson, Mon. Post-tert. Entom., p. 206; pl. xiv., figs. 17, 18.

1886. *Bythocythere pavo*, Malcomson, Proc. Belfast Naturalists' Field Club, p. 261, pl. xxv., figs. 5–7 (*junior*).

Additional localities.—Westport Bay, Ireland, 4 fathoms (G. S. B. and D. R.); St. Magnus' Bay, Shetland (A. M. N.); Belfast Lough and Irish Channel (Malcomson); Dungeness Bay (G. S. B.).

Distribution.—Fosse de Cap Breton, Bay of Biscay, 180–200 fath. (A. M. N.).

Fossil.—Scotland (Crofthead).

We have examined the types of Malcomson's *Bythocythere pavo*, and are satisfied that it is the young of *Bythocythere recta*. It shows the commencement of the future wing-like protuberance, as is slightly indicated in fig. 5 (Malcomson); and the style of surface ornament is that of *B. recta*, which in this respect is unlike any other Ostracod with which we are acquainted. We have met with it in several localities.

6. *Bythocythere dromedaria*, G. O. Sars.

(Plate xx., figs. 11, 12.)

1865. *Bythocythere dromedaria*, G. O. Sars, Oversigt af Norges marine Ostracoder, p. 86.

Shell of *female*, as seen from the side, ovate, greatest height situated in front of the middle, and more than half the length; evenly rounded in front, exserted behind in the form of an obtuse process above the middle; dorsal margin very flexuous, forming a very prominent arch in front, then more deeply sinuated, and as it were impressed; ventral margin gently sinuated in front of the middle, and behind this slightly arcuated. Seen from above, the form is broadly ovate, greatest breadth central, and subequal to the height, lateral margin evenly arched; both extremities, but more especially the hinder, produced and acuminate. Valves thin and pellucid, without any distinct structure, ornamented at both extremities with some radiating lines near the margin. Colour, white. Last joints of the antennules equal in length to the preceding. Second joint of the last feet shorter than the combined length of the two following; terminal nail very slender and almost straight. Termination of the copulatory organs of the male short, subcordiform. No eyes. Length of female, 0·80 mm.

Habitat.—Not common in 30–40 fath., Christiania Fiord, Norway (G. O. Sars).

We are indebted to Prof. G. O. Sars for the type specimens from which our figures are taken.

7. *Bythocythere simplex* (Norman).

(Plate xxiii., fig. 9.)

Synonym: *Bythocythere acuminata*, G. O. Sars.

1868. *Bythocythere simplex*, Brady, Mon. rec. Brit. Ostrac., p. 450, pl. xxxiii., figs. 23–27; and pl. xl., fig. 8.

1874. *Bythocythere simplex*, Brady, Crosskey, and Robertson, Mon. Post-tert. Entom., p. 308, pl. vii., figs. 20, 21.

Additional localities.—Many localities in the Firth of Clyde; coasts of Durham and North Yorkshire, common in depths of 20–45 fath. (G. S. B. and D. R.); St. Magnus' Bay, and ten miles east of Balta, Shetland, 50–73 fath. (A. M. N.); Irish Channel and Belfast Lough (Malcomson).

Distribution.—Dispersed on the Norwegian coast as far north as the Lofoten Islands, in 12–30 fath. (G. O. Sars); Hunde Islands, Baffin's Bay, 60–70 fath. Dr. Sutherland (G. S. B.).

Fossil.—Scotland, Ireland.

8. *Bythocythere recurva*, n. sp.

(Plate xix., figs. 24, 25.)

Shell thin and rather fragile. Seen from the side, subovate, with a rostrate process behind; greatest height anterior, equal to half the length, greatest compression where the shell is highest, gradually becoming less high and more tumid posteriorly, especially towards the ventral margin, a sharp keel surmounting the most tumid part, and running parallel with and above the ventral margin, which lies beneath; anterior margin very widely and obtusely rounded; posterior margin exserted in the form of a beak which curves downwards, and the distal or posterior margin of which is rounded; a few bead-like tubercles stud the anterior and posterior margins just within the borders; dorsal margin nearly straight; ventral margin convex, especially in front. Surface of valves smooth and glassy. Seen from above, subovate, greatest width behind the middle, extremities equally and moderately acuminate. Length, ·5 mm

A single valve of this very distinct form dredged in the Fosse de Cap Breton, Bay of Biscay, 30–60 fath. (A. M. N.).

Genus XII.—Pseudocythere, G. O. Sars.

[Type, *Pseudocythere caudata*, G. O. Sars.]

Pseudocythere caudata, G. O. Sars.

1868. *Pseudocythere caudata*, Brady, Mon. rec. Brit. Ostrac., p. 453, pl. xxxiv., figs. 49–52; pl. xli., fig. 6.
1874. *Pseudocythere caudata*, Brady, Crosskey, and Robertson, Mon. Post-tert. Entom., p. 210, pl. ii., fig. 9.
1880. *Pseudocythere caudata*, Brady, Report "Challenger" Ostracoda, p. 144, pl. i., figs. 6 *a–d*.

Additional localities.—Off north coast of Scotland; Firths of Clyde and Forth; off Red Cliff, Yorkshire, 30 fath.; off Eddystone Lighthouse; Scilly Islands; Clifden, Westport, and Roundstone Bays and Mulroy Lough, Ireland (G. S. B. and D. R.); Shetland; Isle of Skye; off Valentia, Ireland (A. M. N.); Irish Channel and Belfast Lough (Malcomson).

Distribution.—Christiania Fiord, Norway, 30–40 fath. (G. O. Sars); Oster Fiord, 50–100 fath.; off Sartoro, Bergen Fiord, 15–40 fath.; Hardanger Fiord, 25–200 fath., all in Norway; Fosse de Cap Breton, Bay of Biscay, 180–200 fath.; off Isle of Capri, Bay of Naples, 40 fath. (A. M. N.); off Kerguelen Island, 20–120 fath.; off Prince Edward's Island, 50–100 fath., and Stat. 323, lat. 35° 39′ S., long. 50° 47′ W., 1900 fath., "Challenger" (G. S. B.).

Fossil.—Scotland, Ireland.

Genus XIII.—Sclerochilus, G. O. Sars.

[Type, *Sclerochilus contortus* (Norman).]

Sclerochilus contortus (Norman).

1868. *Sclerochilus contortus*, Brady, Mon. rec. Brit. Ostrac., p. 455, pl. xxxiv., figs. 5–10; pl. xli., fig. 7.
1874. *Sclerochilus contortus*, Brady, Crosskey, and Robertson, Post-tert. Entom., p. 212, pl. x., figs. 33–35.
1880. *Sclerochilus contortus*, Brady, Report "Challenger" Ostrac., p. 147, pl. xxxiv., figs. 8 *a*, *b*.

Generally distributed in the British Seas; but rarely taken in abundance. It sometimes occurs between tide-marks, but is more generally met with in deeper water.

Distribution.—Rare, as far north as Finmark (G. O. Sars); Dröbak, 120 fath.; off Sartoro, Bergen Fiord, 15–40 fath.; Kors Fiord, 180 fath.; Hardanger Fiord, off Stordöen, 210 fath., and in Kloster Fiord, 40–80 fath., all in Norway; Holsteinborg Harbour, Greenland; and in Davis Strait, lat. 69° 31′ N., long. 56° 1′ W., 100 fath., "Valorous" Exped.; Naples, shallow water (A. M. N.); rivers Scheldt and Maas, Holland; Spitzbergen, Mr. Lamont (G. S. B.).

Fossil.—Scotland, South Wales, Ireland, Norway, Canada.

Genus XIV.—Cytherideis, T. R. Jones.

[Type, *C. subulata*, Brady. = *Cythere flavida*, Baird; *non* Müller.]

Shell slender, elongate, subovate, tapering and depressed towards the front, not much compressed laterally. Hinge-margins nearly simple; shell smooth, finely punctate; right valve overlapping the left in the centre of the ventral surface. Antennules slender, sparingly setose; last joint short, and bearing six short terminal setæ; penultimate and antepenultimate joints each bearing a single apical seta. Mandible slender and curved, divided below into about four very small indistinct teeth; palp four-jointed, its first joint bearing on the inferior margin a conical tooth-like process; third joint set along its entire length with a comb-like series of straight equal setæ. First segment of the maxillæ much stouter and larger than the rest. In other respects as in *Cythere*.

1. *Cytherideis subulata*, Brady.

1850. *Cythere flavida*, Baird, Brit. Entom., p. 168, pl. xxi., figs. 11, 12 *a* (*non* Müller).
1856. *Cytherideis flavida*, Rupert Jones, Mon. Tert. Entom., England, p. 50, *partim*.
1868. *Cytherideis subulata*, Brady, Mon. rec. Brit. Ostrac., p. 454, pl. xxxv., figs. 43–46.
1872. *Cytherideis subulata*, Brady and Robertson, Ann. and Mag. Nat. Hist., ser. iv., vol. ix., p. 55, pl. i., figs. 12, 13.
1874. *Cytherideis subulata*, var. *fasciata*, Brady and Robertson, Ann. and Mag. Nat. Hist., ser. iv., vol. xiii., p. 117, pl. v., figs. 1–5.
1875. *Cytherideis hilda*, Brady and Robertson, On Dredging off the Durham and North Yorkshire Coasts (Brit. Assoc. Report), p. 187.
1884. *Cytherideis foveolata*, Malcomson, Proc. Belfast Naturalists' Field Club, p. 261, pl. xxv., figs. 8–12.
1885. *Cytherideis subulata*, Carus, Prod. Faunæ Mediterraneæ, p. 303.

Generally distributed round the British coasts, mostly in deep water, but occasionally (as in the Island of Cumbrae) between tide-marks, and not unfrequently also in tidal rivers.

Distribution.—Fosse de Cap Breton, Bay of Biscay, 30–60 fath. (A. M. N.); Eastern Mediterranean, Port Said; Cape Verd Islands; Iceland (G. S. B.).

Fossil.—Crag (England).

This species varies a good deal in shape, size, and surface-markings. The young shell is very regularly and delicately punctated, but the markings become coarser, or are entirely obliterated with age. The form catalogued, but not described, by Messrs. Brady and Robertson, under the name of *C. hilda*, seems to be merely the young of *C. subulata*, while the variety *C. fasciata* is a large local variety

in which the punctured markings are almost absent, and which in the fresh state is conspicuously banded with black, and has a delicate epidermic reticulation. This form is about one-eighth longer than the typical *C. subulata*, and is less compressed in front. The specimens dredged by Dr. Malcomson in the Irish Channel and erroneously referred to *C. foveolata*, we consider to be the young of the present species.

2. *Cytherideis foveolata*, Brady.

(Plate XIX., figs. 19, 20.)

1870. *Cytherideis foveolata*, Brady, Ann. and Mag. Nat. Hist., ser. IV., vol. vi., p. 454, pl. xix., figs. 1–3.

Shell elongate, compressed; seen from the side, siliquose, slightly depressed in front; greatest height situated about the middle, and equal to rather more than one-third of the length; extremities rounded, the anterior much the narrower; dorsal margin almost straight, ventral slightly sinuated in the middle. Seen from above, elongate ovate, widest near the middle, tapering gradually towards the front, more abruptly behind; extremities acuminate; width equal to about one-third of the length. Shell-surface smooth, minutely and somewhat densely punctate, semi-transparent, horny. Length, ·80 mm.

Distribution.—Gulf of St. Lawrence, Mr. G. M. Dawson (G. S. B.); Davis Strait, lat. 60° 55′ N., long. 55° 30′, 57 fath., "Valorous" Expedition, 1875 (A. M. N.).

C. foveolata is larger and more robust than *C. subulata*, and has the valves more conspicuously and densely punctated. Instead of the form, as seen from above, being cuneate, widest behind, and sharply acute in front, in *C. foveolata*, the greatest breadth is central, and the anterior extremity much less acute. In the Greenland specimens, moreover, the margins of the valves at the anterior extremity are denticulated, and there are several concentric raised lines on the infero-anteal portion of the valves.

Genus XV.—Cytherois, Wilh. Müller.

[Type, *Cytherois fischeri* (G. O. Sars).]

Antennules long, six-jointed, sparingly setiferous, second joint very long. Antennæ 3–4 jointed, urticating seta very long, twice geniculated, poison-gland small, last joint with a very strongly-developed terminal seta. Biting portion of the mandible long and slender, without teeth; palp long and slender, two-jointed, beset about the last joint with bristles, branchial appendage rudimentary, consisting of one long seta. Maxilla of the ordinary character, with one very much elongated

and geniculated segment. Mouth broader than usual, with coalescent upper and under lip and rudimentary sucking disc. Shell structureless; hingement of two teeth on the right valve at the front and hinder end of the bar, and a median overlapping edge on the left valve.

Cytherois fischeri (G. O. Sars).

(Plate xxi., figs. 20–22.)

1865. *Paradoxostoma fischeri.* G. O. Sars, Oversigt af Norges marine Ostracoder, p. 96.
1869. *Sclerochilus* (?) *gracilis*, Brady and Robertson, Ann. and Mag. Nat. Hist., ser. iv., vol. iii., p. 372, pl. xx., figs. 11, 12.
1870. *Paradoxostoma fischeri*, Brady, Nat. Hist. Trans. Northumberland and Durham, vol. iii., p. 362, pl. xii., figs. 1–3.
1874. *Paradoxostoma fischeri*, Brady, Crosskey, and Robertson, Mon. Post-tert. Entom., p. 215, pl. xvi., figs. 23, 24.
1884. *Cytherois virens*, Wilh. Müller, Archiv. fur Natugesch., p. 15, pl. ii., figs. 10–13.
1885. *Paradoxostoma fischeri*, Carus, Prod. Faunæ Mediterraneæ, p. 312.
1888. *Paradoxostoma fischeri*, Dahl, Die Cytheriden der Westlich. Ostsee., p. 34, pl. iv., figs. 115–126.

The shell, seen sideways, is subtriangular, highest in the middle, height equal to less than half the length; anterior extremity somewhat narrowed and obliquely rounded, posterior broader and well rounded; superior margin boldly and evenly arched, inferior gently sinuated in the middle. Dorsal view elongated, subovate, thrice as long as broad, broadest in the middle; tapering towards the extremities, which are pointed, the posterior rather the more obtuse. Shell-surface smooth and polished, marked with irregularly disposed dendritic patches of black or dark green. Length, ·65 mm.

This species is so generally distributed round the British shores that it is needless to specify localities; its favourite haunts are amongst algæ between tide-marks and in the laminarian zone; but it occurs also frequently in estuaries and brackish water, as in the rivers and broads of the East Anglian fen district, and has been found as far inland as Whittlesea. In such situations it is usually colourless, but when living amongst algæ it is prettily maculated.

Distribution.—Christiania Fiord, shallow water (G. O. Sars); Sylt, Pomerania (Wilh. Müller); Messina, Sicily (Seguenza).

Fossil.—Scotland, South Wales, Ireland.

Fam. V.—PARADOXOSTOMATIDÆ.

Genus I.—Paradoxostoma, Fischer.

[Type, *Paradoxostoma dispar*, Fischer.]

1. *Paradoxostoma variabile* (Baird).

(Plate xxiii., fig. 10.)

1785 (?). *Cythere flavida*, Müller, Entom., p. 66, pl. vii., figs. 5, 6.
1868. *Paradoxostoma variabile*, Brady, Mon. rec. Brit. Ostrac., p. 459, pl. xxxv., figs. 1–7, 12–17; pl. xli., fig. 8.
1874. *Paradoxostoma variabile*, Brady, Crosskey, and Robertson, Mon. Post-tert. Entom., p. 213, pl x., figs. 29–32.
1888. *Paradoxostoma variabile*, Dahl, Die Cytheriden der Westlich, Ostsee, pl. iv., figs. 127–136.

Generally distributed round the British Islands, between tide-marks and down to about 20 fathoms' depth. Specimens taken amongst seaweeds between tide-marks are usually richly maculated, while those from deep water are often nearly or quite destitute of colour.

Distribution.—Found throughout the coasts of Norway (G. O. Sars and A. M. N.); Holsteinborg Harbour, Greenland: "Valorous" Expedition (A. M. N.); Hunde Islands, Baffin's Bay, 60–70 fath., Dr. Sutherland; and Davis Strait, lat. 67° 17′ N., long 62° 21′ W., laminarian zone; rivers Scheldt and Maas, Holland; Spitzbergen, Mr. Lamont (G. S. B.).

Fossil.—Scotland, Ireland, Norway, Canada.

2. *Paradoxostoma ensiforme*, Brady.

1868. *Paradoxostoma ensiforme*, Brady, Mon. rec. Brit. Ostrac., p. 460, pl. xxxv., figs. 8–11.
1874. *Paradoxostoma ensiforme*, Brady, Crosskey, and Robertson, Mon. Post-tert. Entom., p. 215, pl. x., figs. 27, 28.
1878. *Paradoxostoma ensiforme*, Brady, Ostracoda Antwerp Crag, p. 406, pl. lxiv., fig. 2.
1880. *Paradoxostoma ensiforme*, Brady, Report "Challenger" Ostrac., p. 150, pl. xxxv., figs. 3 *a–d*.
1885. *Paradoxostoma ensiforme*, Carus, Prod. Faunæ Mediterraneæ, p. 312.

This species occurs commonly in the dredge off the coasts of Great Britain and Ireland, and is perhaps quite as widely distributed as the preceding; occurring also, though not so frequently, between tide-marks.

Distribution.—Lervig Bay, Stordöen, Norway, 3–25 fath.; Fosse de Cap Breton, Bay of Biscay, 30–60 fath.; shallow water, Naples, and off the Isle of

Capri, 40 fath. (A. M. N.); Vigo Bay, Spain, 11 fath., "Challenger"; Piræus; Besika Bay; rivers Scheldt and Maas, Holland (G. S. B.).

Fossil.—Crag: England, Antwerp. Post-tertiary: Scotland, England, South Wales, Ireland.

3. *Paradoxostoma abbreviatum*, G. O. Sars.

1868. *Paradoxostoma abbreviatum*, Brady, Mon. rec. Brit. Ostrac., p. 458, pl. xxxv., figs. 22–25.
1874. *Paradoxostoma abbreviatum*, Brady, Crosskey, and Robertson, Mon. Post-tert. Entom., p. 214.
1880. *Paradoxostoma abbreviatum*, Brady, Report "Challenger" Ostrac., p. 150, pl. xxxv., figs. 1 *a–d*.

The distribution of this species, like the last, is general round the British coasts, but it is less numerically abundant, and not so often met with between tide-marks.

Distribution.—Rare; Christiania Fiord, Norway, in laminarian zone (G. O. Sars); Batalden, near Floro, 200 fath.; and Stoksund, in the Hardanger Fiord, 80–100 fath.; Lervig Bay, 3–25 fath.; Lungegaards-vandet, Bergen; Haakelsund, Kors Fiord, all in Norway; Fosse de Cap Breton, Bay of Biscay, 180–200 fath. (A. M. N.); river Scheldt, Holland; also Balfour Bay, Kerguelen Island, 20–50 fath., "Challenger" (G. S. B.).

Fossil.—Scotland, South Wales.

4. *Paradoxostoma obliquum*, G. O. Sars.

1868. *Paradoxostoma obliquum*, Brady, Mon. rec. Brit. Ostrac., p. 459, pl. xxxv., figs. 18–21.

Additional localities.—Lamlash Bay and Cumbrae, Firth of Clyde; Northumberland coast, between tide-marks; off Lantern Hill, Ilfracombe; the Mumbles, South Wales; Scilly Islands; Clifden and Westport Bays, Mulroy Lough, and Lough Swilly, Ireland (G. S. B. and D. R.); Robin Hood's Bay, Yorkshire, tide-marks; Mylor Creek, Falmouth; Valentia Harbour, Ireland (A. M. N.); Irish Channel and Belfast Lough (Malcomson).

Distribution.—Öxfiord, Finmark, very rare (G. O. Sars).

5. *Paradoxostoma normani*, Brady.

1868. *Paradoxostoma normani*, Brady, Mon. rec. Brit. Ostrac., p. 458, pl. xxxv., figs. 39, 40.
1886. *Paradoxostoma truncatum*, Malcomson, Proc. Belfast Naturalists' Field Club, p. 262, pl. xxv., figs. 3, 4.
1886. *Sclerochilus contortus*, var. *abbreviatus*, Brady and Robertson, Ann. and Mag. Nat. Hist., ser iv., vol. iii., p. 372, pl. xx., figs. 15, 16.

Additional localities.—Montrose Basin; Seaton Sluice and Budle Bay, Northumberland; off the Durham coast, 10–20 fath.; off Robin Hood's Bay, Yorkshire, 30 fath.; Dungeness Bay; among the Scilly Isles; and in Westport and Roundstone Bays, and Lough Swilly, Ireland (G. S. B. and D. R.); among laminariæ, Bressay Sound, and St. Magnus' Bay, also 5–8 miles east of Balta, Shetland, 5–50 fath., living; Whitby, Yorkshire, 5 fath.; Dartmouth Harbour (A. M. N.); Irish Channel, and Rockport, Co. Down (Malcomson).

Distribution.—Fosse de Cap Breton, Bay of Biscay, 180–200 fath. (A. M. N.).

Having examined specimens of Mr. Malcomson's *P. truncatum*, we are satisfied that it is only a form of the present species. In the specimens with which he favoured us before his lamented death, there is no such decided angle at the infero-anteal corner as is represented in his figure 3, that angle being much more rounded off.

6. *Paradoxostoma pulchellum*, G. O. Sars.

(Plate XXI., figs. 29, 30.)

1868. *Paradoxostoma pulchellum*, Brady, Mon. rec. Brit. Ostrac., p. 459, pl. xxxv., figs. 41, 42.
1870. *Paradoxostoma pulchellum*, Brady and Robertson, Nat. Hist. Trans. Northumberland and Durham, p. 363, pl. xii., figs. 4, 5.

Additional localities.—Loch Ryan; Firth of Clyde; Boulmer, Northumberland; Hartlepool, tide-marks; Roundstone Bay and Mulroy Lough, Ireland (G. S. B. and D. R.); Loch Carron; Arran, N.B.; Falmouth (A. M. N.); Belfast Lough (Malcomson).

Distribution.—Vallö, Christiania Fiord, rare (G. O. Sars); Lervig Bay, Stordöen, Norway (A. M. N.).

7. *Paradoxostoma hibernicum*, Brady.

(Plate xxi., figs. 15–17.)

1868. *Paradoxostoma hibernicum*, Brady, Mon. rec. Brit. Ostrac., p. 460, pl. xxxv., figs. 35, 36; and pl. xl., fig. 7.

1868. *Paradoxostoma sarniense*, idem, ibidem, p. 460, pl. xxxv., figs. 26–29, pl. xl., fig. 9.

1870. *Paradoxostoma hibernicum*, Brady and Robertson, Nat. Hist. Trans. Northumberland and Durham, vol. iii., p. 362, pl. xii., figs. 10, 11.

During the last twenty years, having had opportunities of seeing this species from many localities, we have come to the conclusion that *L. sarniense* must be united with it.

The great flattening of the ventral margin, especially on the posterior half, where it is much expanded, combined with the usual presence in it of fine transverse opaque white lines are points which especially characterize this species, though partially shared by *P. flexuosum*, as well as by the genus *Machærina.*

Additional localities.—Firth of Clyde; Budle Bay, Seaton Sluice, and Boulmer, in Northumberland; Durham coast, 20–30 fath.; Scilly Islands; Clifden, Birturbuy and Westport Bays, and Lough Swilly, Ireland (G. S. B. and D. R.); Filey Brig, Yorkshire; Clew Bay and Valentia Harbour, Ireland (A. M. N.); Rockport, Co. Down (Malcomson).

8. *Paradoxostoma vitreum*, G. O. Sars.

(Plate xxi., figs. 27, 28.)

1865. *Paradoxostoma vitreum*, G. O. Sars, Oversigt af Norges marine Ostracoder, p. 95.

Shell of *female*, seen from the side, elongated, subovate, higher behind than in front; greatest height behind the middle, and less than half the length; anterior extremity narrowly rounded, point of greatest projection central; posterior extremity broadly and obtusely rounded; dorsal margin forming a depressed arch, flattened centrally, front declination gentle, behind the middle moderately arcuate, and at the hinder extremity descending nearly perpendicularly; ventral margin very slightly sinuated in the centre. Seen from above, the outline is narrowly ovate, greatest breadth central, and less than the greatest height. "Shell of the *male* much more elongated and narrower, nearly three times as long as high. Antennules very long and very slender, second joint greatly elongated, three

following joints subequal to each other, their combined length about equal to that of the second joint; antennæ moderately strong, the second joint larger than usual, the last furnished with two nails of unequal length. Mandibles more robust than usual, inferior extremity obtusely acuminate. First maxillæ having three unequal lobes. Feet having the two distal joints subequal. Extremity of the copulatory organs of the male subtriangular, obtusely angulated in front, somewhat exserted behind. Length of female, ·51 mm.; of male, ·53 mm."

Habitat.—Balta Sound, Shetland, laminarian zone (A. M. N.).

Distribution.—Thorshaven, Faroe Islands, collected by Mr. E. C. Davison (G. S. B.); rare in 6–12 fath. in the Christiania Fiord, and also at Langesund, Norway, at the same depth (G. O. Sars); Lervig Bay, Stordöen, Norway, 3–25 fath. (A. M. N.)

We are indebted to Professor G. O. Sars for types of this species, with which our own have been compared. In the young the broad posterior extremity is not so much developed, and at this age it approaches very closely to the young of *Cytherois fischeri*, from which it differs in its very compressed form, and much less concave ventral margin. The young of *P. pulchellum* also approaches this form, but is higher in proportion to the length.

9. *Paradoxostoma fasciatum*, n. sp.

(Plate xxi., figs. 25, 26.)

Shell, seen laterally, elongated, subovate, somewhat depressed in front, greatest height situated behind the middle, and equal to more than one-third of the length; anterior extremity rounded and somewhat flattened, posterior evenly rounded; dorsal margin forming a flattened arch, with one continuous curve from end to end, but more convex behind; ventral margin somewhat convex, faintly sinuated near the middle. The outline, seen dorsally, is much compressed, fusiform, with sharply-pointed extremities, five times as long as broad. Surface of the valves smooth and polished, marked with a broad median black band; edges, especially those of the posterior and ventral portions, much compressed. Length, ·84 mm.

Habitat.—Jersey (A. M. N.); Clew Bay, Co. Mayo, 2–4 fath. (G. S. B. and D. R.).

This species is extremely like *P. vitreum*, Sars, but is larger and much more compressed, and both ventral and dorsal margins are more protuberant behind the middle; the black transverse band is also characteristic.

10. *Paradoxostoma arcuatum*, Brady.

(Plate xxi., figs. 5, 6.)

1868. *Paradoxostoma* (?) *arcuatum*, Brady, Mon. rec. Brit. Ostrac., p. 461, pl. xxxv., figs. 37, 38.
1874. *Paradoxostoma arcuatum*, Brady, Crosskey, and Robertson, Mon. Post-tert. Entom., p. 217.

A rare species, of which only a single specimen was known at the time of the publication of Dr. Brady's Monograph. It has since been found in the following localities, but is apparently everywhere very rare:—St. Magnus' Bay, Shetland; Dartmouth Harbour; Roundstone Bay, Ireland (A. M. N.); Clifden Bay, Ireland; Granton (G. S. B. and D. R.).

Fossil.—Raised-beach, at Oban, Scotland.

11. *Paradoxostoma orcadense*, Brady and Robertson.

(Plate xxi., figs. 18, 19.)

1872. *Paradoxostoma orcadense*, Brady and Robertson, Ann. and Mag. Nat. Hist., ser. iv., vol. ix., p. 53, pl. i., figs. 5–7.
1874. *Paradoxostoma cuneatum*, Brady and Robertson, Ann. and Mag. Nat. Hist., ser. iv., vol. xiii., p. 117, pl. v., figs. 6, 7.

Carapace, as seen from the side, elongated, subreniform or subtriangular, highest near the middle, lower in front than behind; height equal to two-fifths of the length; extremities well rounded, the anterior being rather the narrower; superior margin sloping at first gently forwards almost in a right line from its highest point, but well arched behind; inferior sinuated in the middle. Seen from above, ovato-cuneate, widest near the posterior extremity; width equal to nearly one-third of the length, subacuminate in front, rounded behind. Animal unknown. Length, ·55 mm.

Habitat.—Stromness Bay, Orkney, sandy bottom; White Bay, Cumbrae, and off Glen Sannox, Arran; dredged in New Grimsby Harbour, and off St. Mary's, Scilly; Berehaven, Ireland (G. S. B. and D. R.).

The Scilly specimens are smaller and rather more angular than the types, and were at first supposed to be distinct (described as *P. cuneatum*), but further examination leads us to conclude that they belong properly to *P. orcadense*.

Distribution.—Lervig Bay, Norway, a single specimen; Fosse de Cap Breton, Bay of Biscay, 180–200 fath. (A. M. N.).

12. *Paradoxostoma hodgei*, Brady.

(Plate xxi., figs. 7, 8.)

1870. *Paradoxostoma hodgei*, Brady, Nat. Hist. Trans. Northumberland and Durham, vol. iii., p. 371, pl. xii., figs. 12, 13.

Carapace, seen from the side, elongated, subreniform; greatest height situated in the middle, and not much exceeding one-third of the length; extremities narrowed and rounded, the posterior the narrower; superior margin boldly and evenly arched, inferior sinuated in the middle, behind the sinuation well arched, and curving gently upwards towards the extremity. Seen dorsally, the outline is compressed, linear-ovate, about five times as long as broad, widest in the middle, and tapering gradually and equally to the extremities, which are subacutely pointed. Shell smooth and polished, transparent, yellowish. Length, ·65 mm.

Dredged off the Durham coast; off Callum's Bay, Bute, and in Lough Swilly, Ireland (G. S. B. and D. R.); off Tarbert, Loch Fyne, 25 fath. (A. M. N.).

13. *Paradoxostoma rostratum*, G. O. Sars.

(Plate xxiii., figs. 3, 4.)

1865. *Paradoxostoma rostratum*, G. O. Sars, Oversigt af Norges marine Ostracoder, p. 97.

Shell, seen from the side, elongated, narrowly subelliptical, greatest height nearly central, much less than half the length; anterior extremity very narrow, obtusely pointed, and slightly curved downwards; posterior extremity obtusely rounded; dorsal margin evenly arcuate; ventral margin perfectly straight throughout its entire length. Seen from above, the outline is nearly equally broad in front and behind; lateral margins nearly straight, and subparallel in the middle, greatest breadth rather less than the height, both extremities acuminate. Valves thin, smooth, horny; their ventral margin moderately thickened, and laterally more emarginate than usual towards the front; dorsal margin of the left valve slightly prominent in the middle. Anterior extremity of the valves protected by a rounded concave laminar process. Animal unknown. Length, ·74 mm.

Habitat.—Very rare at Öxfiord, Finmark (G. O. Sars).

The foregoing is Sars' description of the species, and the illustration we are enabled to give is from an outline drawing, which he has most kindly sent to us.

14. *Paradoxostoma productum*, n. sp.

(Plate xxi., figs. 9, 10.)

Shell of *male* (?), seen from the side, siliquose, much curved, greatest height behind the middle, about equal to one-third of the length; anterior margin most produced above the middle, to which point the dorsal margin evenly and arcuately slopes, below this point of furthest projection the margin slopes obliquely; posterior margin much exserted, the sides sloping above and below to a central narrowly-produced rounded point; dorsal margin well and evenly arched throughout, in front right down to the extremity, behind extended nearly horizontally at the pointed termination; ventral margin in front of the middle deeply concave, behind the middle boldly arched, the hinder half of the shell being much higher than the anterior half. Seen from above, the outline is very narrow and elongated, greatest width central, much less than the height, and not one-fourth of the length; sides evenly but lowly arched, extremities equally acuminate and pointed. Valves white, perfectly smooth, and lustrous. Length, ·55 mm. Shell of *female* (?) smaller, of similar shape, but not quite so produced behind, more tumid, greatest breadth equal to the height. Length, ·40 mm.

Of the larger form, which we have called the male, we have only seen two specimens, the smaller form was taken with it; but in the other three localities the latter only was found. A specimen of the smaller form, of which we have examined the animal, appears to be a female; but we have not been able to determine the sex of the larger form.

As yet only found in Norway; off Sartoro, in the Bergen Fiord, in 15–40 fath.; Lervig Bay, Stordöen, 25 fath.; and in two places in Stocksund, which is near the mouth of the Hardanger Fiord, in 80–100, and in 126 fath. (A. M. N.).

15. *Paradoxostoma flexuosum*, Brady.

(Plate xxi., figs. 11, 12.)

1868. *Paradoxostoma flexuosum*, Brady, Mon. rec. Brit. Ostrac., p. 461, pl. xxxv., figs. 31–34.

1872. *Paradoxostoma flexuosum*, Brady and Robertson, Ann. and Mag. Nat. Hist. ser. iv., vol. ix., p. 55, pl. i., figs. 8, 9.

1874. *Paradoxostoma flexuosum*, Brady, Crosskey, and Robertson, Mon. Post-tert. Entom., p. 216, pl. xvi., figs. 19, 20.

1874. *Paradoxostoma tenerum*, iidem, ibidem, p. 217, pl. xvi., figs. 21, 22.

The form described under the name *Paradoxostoma tenerum*, in the "Monograph of the Post-tertiary Entomostraca," is probably only the female of *P. flexuosum.*

We have seen it in several dredgings associated with the latter species; but never having been fortunate enough to find any but empty shells, we are unable to speak with absolute certainty in the matter. In the following list of localities *f.* or *t.* imply that the forms *flexuosum* or *tenerum* were observed:—

Additional localities.—North coast of Scotland; Stromness; Firths of Forth and Clyde; off the Durham and North Yorkshire coasts; rivers Ouse and Humber; Scilly Isles; Penarth Head; Dungeness Bay; Eddystone Lighthouse; Birturbuy, Clifden, Westport, and Roundstone Bays, and Loughs Swilly and Mulroy, Ireland (G. S. B. and D. R.); Shetland, *f.* and *t.*; Inverary, 25–40 fath., *t.*; off Skipness, Loch Fyne, *f.*; Dartmouth Harbour, *f.* and *t.*; Valentia Harbour, Ireland, *f.* and *t.* (A. M. N.); Irish Channel and Belfast Lough, *f.* (Malcomson).

Distribution.—Rivers Scheldt and Maas, Holland (G. S. B.); Oster Fiord, 100–200 fath., *f.*; off Sartoro, Bergen Fiord, 15–40 fath., *f.*; Lervig Bay, Hardanger Fiord, 3–25 fath., *f.* and *t.*; Dröbak, in the Christiania Fiord, 30–100 fath; Fosse de Cap Breton, Bay of Biscay, 180–200 fath.; Davis Strait, lat. 69° 31′ N., long. 56° 1′ W. 100 fath., "Valorous" Exped. (A. M. N.).

This is an extremely variable species, differing in amount of arcuation of the dorsal margin, and degree of sinuation of the ventral, and in the proportions of height and length; also in the narrower or broader extremities, and in the amount of convexity; but we have seen so many intermediate links that, different as the forms at first sight appear, we are unable to recognise them as distinct species.

Genus II.—Machærina (μάχαιρα, a knife).

= *Xiphichilus*, Brady (name preoccupied among Pisces).

[Type, *Machærina tenuissima* (Norman).]

Shell very thin and fragile, smooth, glassy, pellucid; valves compressed, elongate, pointed at both ends, nearly equal; ventral margins much compressed, forming a flattened, knife-like plate, which is widest behind the middle, and marked by several opaque transverse hair-like lines. Outline, as seen from above, compressed, tapering evenly from the middle to each extremity. Hinge simple. Limbs excessively long and slender. Antennules six-jointed and quite destitute of setæ. Antennæ sparingly setiferous. Mandibles very long and slender, styliform, palp (?) biarticulate, slender and terminating in two long setæ. Abdomen produced into two long tapering processes, which are destitute of claws.

1. *Machærina tenuissima* (Norman).

(Plate xxi., figs. 13, 14.)

1868. *Bythocythere tenuissima*, Norman, Last Report Dredging among the Shetland Isles, Brit. Assoc. Report, p. 294.
1870. *Xiphichilus tenuissima*, Brady, Nat. Hist. Trans. Northumberland and Durham, vol. iii., p. 369, pl. xii., figs. 6–9 ; and pl. xiv., figs. 5–10.

Elongated, doubly fusiform, extremities equal and gradually attenuated to acute points. Seen from the side, the outline is slender, flexuous, with very produced mucronate extremities, four times as long as broad, the greatest height being near the middle; dorsal margin regularly arched ; ventral flexuous but slightly convex, especially behind the middle, where the margins of the valves are much appressed so as to form a sharp, knife-like flange. Dorsal view excessively compressed and elongated, quite five times as long as broad, tapering equally from the middle to the extremities, which are very acute and attenuated. Surface perfectly smooth. Antennules excessively slender, having the first four joints of nearly equal length, and about nine times as long as broad, the last two about one-third the length of the preceding. Antennæ having a single seta at the apex of each joint, and one in the middle of the penultimate; urticating seta long and slender, triarticulate; last leg having the second joint excessively long, the third about one-fourth, and the last one-half of its length, claws long, slender, and slightly curved. Length, 1·15 mm.

Dredged in St. Magnus' Bay, Shetland, 30–60 fath. ; off Fairlie, Firth of Clyde, Roundstone Bay, Killary Bay, and off Valentia, Ireland (A. M. N.); off the Island of Cumbrae; Kilchattan Bay, Bute; off Skelmorlie, Ayrshire ; off the Durham coast, 15–30 fath. ; off Great Ormes Head (G. S. B. and D. R.); Belfast Lough (Malcomson).

2. *Machærina amygdaloides* (Brady).

(Plate xvii., figs. 20, 21.)

1870. *Xiphichilus amygdaloides*, Brady, Nat. Hist. Trans. Northumberland and Durham, vol. iii., p. 370, pl. xiii., figs. 8–10.

Shell, as seen from the side, oblong-oval, or almond-shaped, gently tapering to the extremities, which are much narrowed, rounded, and nearly equal in height; superior margin gently and evenly arched, but slightly sinuated in front of the

middle; ventral margin sinuated in the middle, behind which it pouts considerably; greatest height in the middle, and equal to rather more than one-third the length. Seen from above, the outline is much compressed, rhomboidal, or doubly fusiform, tapering equally from the middle, where it is widest, to the acutely-pointed extremities; greatest width scarcely equal to half the height, and to about one-fifth of the length; surface perfectly smooth, the transverse opaque lines of the knife-like ventral margin very conspicuous when seen from below. Animal unknown. Length, ·55 mm.

One British specimen only known, found by Mr. D. Robertson among sand dredged off Papa, Shetland.

Distribution.—Fosse de Cap Breton, Bay of Biscay, 180–200 fath., a single specimen; Bay of Naples, shallow water, three specimens (A. M. N.).

Although so few specimens have been found of this species, it would seem to have a wide geographical range. One of the Naples specimens differs from the others in being longer in proportion to the height, and in having the posterior extremity extended centrally in a sort of rostrate process, with rounded termination. This, perhaps, may prove to be the male.

APPENDIX.

OSTRACODA OF THE FRENCH GOVERNMENT'S EXPEDITIONS IN THE "TRAVAILLEUR" AND "TALISMAN."

During the progress of this work there have been kindly sent to us by our friend the Marquis de Folin some Ostracoda which he has picked out from the dredgings of the French Government Expeditions in the "Travailleur" and the "Talisman." Some of these species are from dredgings which fall within the limits of the present Paper; others are from off the coast of Africa; but all are from such great depths that they may be expected hereafter to be found to have a wide range over the bed of the North Atlantic. Under these circumstances we have considered it best to notice them in an Appendix, more especially as the greater number of the forms will be found described in preceding pages.

3. *Bairdia subcircinata*, Nobis (see p. 113).

1880. *Bairdia formosa*, Brady, Ostracoda of the "Challenger" Expedition, p. 52, pl. x., figs. 1 *a–e*.
(Not *B. formosa*, Brady, Ann. and Mag. Nat. Hist., 1868.)

Dredged by the "Talisman," in a depth of 2200 mètres, June 23rd, 1883, and in 1918 mètres, lat. 27° 31′ N., long. 16° 27′ W.

5. *Bairdia victrix*, Brady (see p. 115).

Well-characterised specimens were found in material dredged by the "Talisman" in 1918 mètres, lat. 27° 31′ N., long. 16° 27′ W.; in 2334 mètres near the "Arguin Bank;" and in 836 to 1350 mètres off the west coast of Morocco.

8. *Bairdia simplex*, Brady.

1880. *Bairdia simplex*, Brady, Report "Challenger" Ostracoda, p. 51, pl. vii., figs. 1 *a–d*.

Shell, viewed laterally, oblong, subovate, nearly twice as long as high; extremities rather narrow; anterior much broader than the posterior, evenly

rounded; dorsal margin arched, ventral straight, or slightly convex. The outline, as seen from above, is compressed, ovate, about twice as long as broad, widest in the middle, extremities subacuminate. End view broadly ovate, widest in the middle, width equal to two-thirds of the height. Shell-surface smooth, with a few scattered hairs. Length, 1·3 mm.

A single specimen only, from 4060 mètres. It was procured in 1883, but there is nothing further to show the habitat.

9. *Bairdia abyssicola*, Brady.

1880. *Bairdia abyssicola*, Brady, Report "Challenger" Ostracoda, p. 52, pl. vii., figs. 4 *a–c*.

Shell, seen from the side, subreniform; highest in the middle; height equal to about three-fifths of the length; anterior extremity much compressed at the edge, broadly rounded, and, as it were, bent downwards; posterior rounded, somewhat narrowed, and flattened, and produced below the middle; dorsal margin very boldly arched throughout; ventral sinuated in the middle. Seen from above, the outline is narrowly ovate, compressed at the extremities, which are acute. Surface of shell quite smooth and polished. Length, ♀. 1·5 mill., ♂. 1·8 m.

The specimens above described exactly correspond with the figure in "Challenger" Report, 4 *b*, there called the right valve, except that the dorsal sinuation near the anterior extremity is either altogether absent, or in other cases less pronounced, than is represented in that figure. With these specimens occur others, which we suppose to be males. In these, while the general characters are preserved, the height is much less in proportion to the length, and the dorsal margin is straight in its central portion; the general form, therefore, is more elongated.

Bairdia abyssicola, × 30.

The leading character of the species is the marked compression of the shell at the extremities. The left valve is much larger than the right, and overhangs it dorsally, in a similar manner to that of *Bythocypris bosquetiana*. (See pl. XIV., fig. 4.)

In "Talisman" dredging in 2200 mètres, June 23, 1883.

10. *Bairdia folini*, Brady.

1886. *Bairdia folini*, Brady, Les Fonds de la Mer, vol. iv., p. 195, pl. xiv., figs. 4, 5.

Shell, viewed laterally, having the dorsal margin boldly arched in front, terminating in a very broadly-rounded anterior margin, which has no angularity either above or below, and the greatest projection of which is central; behind, the dorsal curve continues downwards, until a narrow, well-rounded posterior termination is formed, the whole of which termination lies below the central line of the shell; ventral margin straight, but with a slight symptom of sinuosity. Greatest height central, subequal to half the length. Seen from above, the outline is narrowly ovate, greatest breadth central, equal to nearly half the length; anterior extremity subacute, posterior acute. Surface of valves perfectly smooth and polished, without hairs, and without spines. Length, 1·75 m.

Dredged by the "Talisman," August 24th, 1883, in 4060 mètres.

In form this somewhat resembles *B. abyssicola*, but is very distinct; the valves are subequal, the left not being, as in that species, much larger than the right, and overhanging the latter dorsally; the posterior extremity is narrower, the convexity is greater, and the extremities have not the remarkable compression of *B. abyssicola*.

Bairdia folini, × 25.

11. *Bairdia affinis*, Brady.

1886. *Bairdia affinis*, Brady, Les Fonds de la Mer, vol. iv., p. 195, pl. xiv., figs. 6, 7.

Shell, seen from the side, subreniform, the left valve much larger than the right, less sinuated in outline, and overlapping at all points except in front; greatest height situated in the middle, and equal to three-fifths of the length; anterior extremity broad, obliquely subtruncate, scarcely rounded; posterior narrow, not produced, rounded, and forming, with the dorsum, one continuous, boldly-arcuate curve; inferior margin slightly sinuated in the middle, and very gently upcurved behind. Seen from above, the outline is compressed, oval, widest in the middle, about twice and a-half as long as broad, only slightly tapered towards the extremities, which

Bairdia affinis, × 40.

are equal and subacute. Surface of the shell perfectly smooth. Length, 1·05 mm.

One specimen only of this species was found in a dredging made by the "Talisman," on the 7th of July, 1883, in a depth of 1918 mètres.

12. *Bairdia hirsuta*, Brady.

1880. *Bairdia hirsuta*, Brady, Ostracoda of the "Challenger" Expedition, p. 50, pl. viii., figs. 3 *a–d*.

Habitat.—Strait of Bocayna, between Lanzarote and Fuerteventura, Canary Islands; coast of Soudan, 932 mètres, July 12th, and 2334 mètres, July 15th, 1883; west coast of Morocco, 836 mètres, 17th June, 1883.

1. *Macrocypris minna* (Baird), (see p. 117).

In lat. 28° 35′ N., long. 15° 36′ W., 1238 mètres; lat. 32° 31′ N., long. 12° 08′ W., 1350 mètres; off west coast of Morocco, June, 1883, 636–1200 mètres; and in lat. 23° N., long. 19° 50′ W., 932 mètres.

2. *Macrocypris angusta* (G. O. Sars), (see p. 117).

In lat 23° N., long 19° 50′ W., 932 mètres.

3. *Macrocypris siliquosa*, Brady (see p. 118).

Localities.—West coast of Morocco, 630, 836, 1350 mètres; in lat. 23° N., long. 19° 50′ W., 932 mètres; in lat. 20° N., 2333 mètres; lat. 32° 31′ N., long. 12° 08′ W., 1350 mètres.

Bythocypris bosquetiana (Brady), (see p. 120).

One specimen dredged near the Arguin Bank, lat. 20° N., 2333 mètres; others in a depth of 932 mètres, lat. 33° N., long. 19° 50′ W.; and West coast of Morocco, 836 to 1200 mètres.

13. *Cythere sulcifera*, Brady (see p. 133).

Well-developed and characteristic specimens of this species were dredged by the "Talisman," June 16th, 1883, lat. 32° 31′ N., long. 12° 08′ W., in 1315 mètres; July 7th, 1883, lat. 27° 31′ N., long. 16° 27′ W., 1918 mètres; and June 27th, 1883, east of the Canary Islands, 975 mètres.

39. *Cythere echinata*, G. O. Sars (see p. 150).

Between "la mer des Gargattes" and the Azores; and 11th August, 1883, 2792 mètres; "Coast of Soudan," 932 mètres; west coast of Morocco, 836 mètres, 17th June, 1883; in lat. 25° 01′ N., long. 19° 15′ W, 2638 mètres; in lat. 28° 35′ N., long. 15° 36′ W., 1238 mètres; and in other localities of which we have not full particulars.

40. *Cythere acanthoderma*, Brady (see p. 151).

North of St. Michael, Azores, in 2295 mètres.

41. *Cythere dictyon*, Brady (see p. 152).

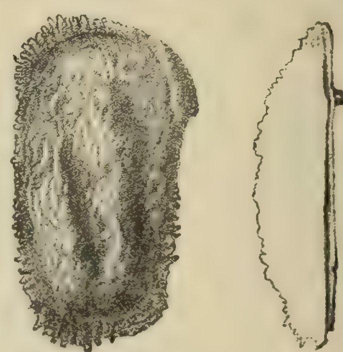
North of St. Michael, Azores, 2995 mètres, and 4000 mètres; between the Azores and the Bay of Biscay, 5005 mètres; and between "la mer des Gargattes" and the Azores.

50. *Cythere emaciata*, Brady (see p. 159).

An elongated variety of this species, in which the height is less than usual, but of which only a single example occurred, was procured by the "Talisman" in 2995 mètres, to the north of St. Michael, Azores.

69. *Cythere milne-edwardsii*, n. sp.

Shell, viewed laterally, oblong; height nearly equal throughout, but greatest quite in front in a line with the hinge joint, which is very prominent, and situated in a very forward position; anterior and posterior extremities obliquely truncate, the obliquity only slight, in both instances the greatest projection is below; all four corners completely rounded off; dorsal and ventral margins straight and parallel, the ventral only slightly longer than the dorsal. Surface of valves rugose, with depressed tubercles and small blunt spines, none of which are conspicuous above the rest by greater size; two low and indistinct riblets pass longitudinally and convergingly along the middle portion of the shell, not reaching the front, and roundly united in a loop-like manner at a short distance from the posterior extremity. Seen from above, the sides are gently convex, converging rather abruptly in front and more gradually behind, and everywhere showing an irregularly sinuous and dentated outline. Length, 1 mm.



Cythere milne-edwardsii, × 40.

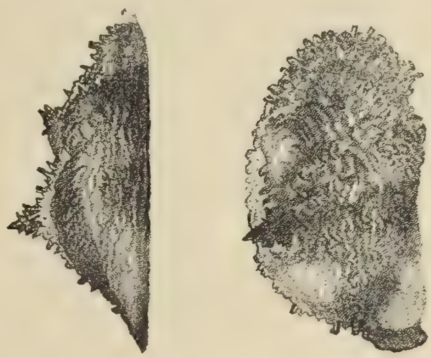
Dredged by the "Talisman" off the west coast of Morocco, 836 to 1200 mètres, and near the "Arguin Bank," Africa, lat. 20° N., July 15, 1883, in 2333 mètres.

We have named this species after Professor Alphonse Milne-Edwards, under whose direction the "Talisman" exploration was conducted.

70. *Cythere scaberrima*, Brady.

1886. *Cythere scaberrima*, Brady, Les Fonds de la Mer, vol. iv., p. 198, pl. xiv., figs. 10, 11.

Shell of peculiar shape; height equal to nearly half the length; dorsal margin gently arched, ventral nearly straight; anterior extremity widely and somewhat obliquely rounded, greatest projection above the middle; posterior margin very obliquely truncate, sloping backwards from above, and so projected below that the ventral margin is much longer than the dorsal, and at the infero-posteal corner the union of the ventral and posterior margins is projected backwards in beak-like manner, with truncated apex. Seen from above, the outline (of the single valve) is triangular, widest behind the middle, the anterior portion very much broken and spinous, the posterior somewhat less so. Surface of the shell very rugose; across the centre of the valves is a deep sinus, in front of and behind which the surface rises in an umbonal manner, while towards the dorsal margin these protuberances terminate in two much elevated, rugged and acutely-pointed spikes; the whole surface of the valves, including the spikes, to their very summit, is covered with spines, subequal in size, though a few at the margins are somewhat larger than the rest. In the interior of the valves the margins of the extremities are widely outspread and thickened; across their centre runs a strong transverse bar, in front and behind which are two deep sinuses, which are represented externally by their umbonal protuberances. Length, 1·1 mm.


Cythere scaberrima, × 40.

A single valve only, from a "Talisman" dredging, made on 7th August, 1883, in 3535 mètres.

4. *Xestoleberis margaritea*, Brady (see p. 190).

1866. *Cytheridea margaritea*, Brady, Trans. Zool. Soc., vol. v., p. 370, pl. lviii., figs. 6 *a–d*.

The types of this species, being picked out of sponge-sand, were, of course, merely empty, bleached shells. They agree, however, very closely in shape with specimens sent to us by the Marquis de Folin, which were dredged off Muros, Galicia, and are also all empty shells. But Dr. Norman's collection contains specimens from the Bay of Naples undoubtedly identical with those from Muros, containing the soft parts of the animal, and showing the natural coloration of the shell—yellowish, with three dark transverse bands, or blotches, on each valve.

Xestoleberis margaritea, × 75.

We do not now consider the specimens called *X. margaritea* in the "Challenger" Report to be rightly referred to that species. We give here drawings of the Neapolitan form, and on re-examination of specimens from the several localities, we no longer entertain the opinion expressed in the body of this memoir (p. 190) as to the identity of *X. intermedia* with this species.

2. *Krithe producta*, Brady (see p. 180).

Dredged by "Talisman," in 4060 mètres; locality not stated; also lat. 25° 1′ N., long. 19° 15′ W., 2638 mètres.

13. *Cytheropteron mucronalatum*, Brady (see p. 215.)

Between the Azores and the Bay of Biscay, 27th August, 1883, 5005 mètres.

EXPLANATION OF PLATE XXXV.

PLATE XXXV.

LETTERING ADOPTED IN ALL THE FIGURES.

a.,	acontia.	*m. f.*,	mesenterial filament.	*s. d.*,	sulcar directive mesentery
ax. t.,	axial tentacle.	*n.*,	nucleus.	*s. l. en.*,	sulco-lateral endocœle.
c. m.,	circular muscle.	*œs.*,	sophagus.	*sl.*,	sulculus.
c. m. en.,	circular muscles of endoderm.	*œs. gr.*,	œsophageal groove.	*sl. d.*,	sulcular directive mesentery.
cu.,	cuticle.	*ov.*,	ovum.	*sl. en.*,	sulcular endocœle.
d.,	directive mesenteries.	*p. d.*,	pedal disk.	*sl. ex.*,	sulcular exocœle.
ec.,	ectoderm.	*p. m.*,	parietal muscle.	*sl. l. en.*,	sulculo-lateral endocœle.
en.,	endoderm.	*r. m.*,	retractor muscle.	*s. l. m.*,	sulco-lateral mesentery.
g. s.,	grains of sand.	*sc.*,	sucker.	*sl. l. m.*,	sulculo-lateral mesentery.
l. ex.,	lateral exocœle.	*s.*,	sulcus.	*sp.*,	sperm-cell.
m.,	mesoglœa.	*s. en.*,	sulcar endocœle.	*z.*,	zooxanthellæ.
		s. ex.,	sulcar exocœle.		

Halcampa chrysanthellum (Peach).

Figure.

1. Transverse section through œsophageal region, $\times \frac{2}{a * 10}$ = about 14 diam.
2. Transverse section through generative region of body, $\times \frac{2}{a * 10}$.

Halcampa arenarea, Haddon.

3. Transverse section through œsophageal region, × 10 diam.

Chondractinia nodosa (Fabricius).

4. Vertical section through the body of a preserved specimen; natural size.

Chondractinia digitata (O. F. Müller).

5. Part of a transverse section through the œsophageal region (the spaces in the mesoglœa appear to be due to some imperfection in the method of preparation), $\times \frac{4}{a * 10}$.
6. Transverse section of a tertiary mesentery, $\times \frac{4}{A}$.
7. Vertical section through the specimen drawn in fig. 12, pl. xxxiii., × 2 diam.

Chitonactis marioni, n. sp.

8. Vertical section through upper portion of the body-wall, including the sphincter muscle, $\frac{4}{a * 10}$.
9. Transverse section through a mesentery, $\frac{2}{A}$.

Hormathia margaritæ, Gosse.

10. Vertical section through the circular muscle, $\times \frac{3}{a * 10}$.
11. Detail of muscle of previous figure.
12. Transverse section through body-wall and secondary mesentery, $\times \frac{3}{A}$.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12.

EXPLANATION OF PLATE XXXVI.

PLATE XXXVI.

LETTERING ADOPTED IN ALL THE FIGURES.

a., . . .	acontia.	*m. f.*, . .	mesenterial filament.	*s. d.*, . .	sulcar directive mesentery.
ax. t., . .	axial tentacle.	*n.*, . . .	nucleus.	*s. l. en.*, .	sulco-lateral endocœle.
c. m., . .	circular muscle.	*œs.*, . . .	œsophagus.	*sl.*, . . .	sulculus.
c. m. en., .	circular muscles of endoderm.	*œs. gr.*, .	œsophageal groove.	*sl. d.*, . .	sulcular directive mesentery.
cu., . . .	cuticle.	*ov.*, . . .	ovum.	*sl. en.*, . .	sulcular endocœle.
d., . . .	directive mesenteries.	*p. d.*, . .	pedal disk.	*sl. ex.*, . .	sulcular exocœle.
ec., . . .	ectoderm.	*p. m.*, . .	parietal muscle.	*sl. l. en.*, .	sulculo-lateral endocœle.
en., . . .	endoderm.	*r. m.*, . .	retractor muscle.	*s. l. m.*, .	sulco-lateral mesentery.
g. s., . .	grains of sand.	*sc.*, . . .	sucker.	*sl. l. m.*, .	sulculo-lateral mesentery.
l. ex., . .	lateral exocœle.	*s.*, . . .	sulcus.	*sp.*, . . .	sperm-cell.
m., . . .	mesoglœa.	*s. en.*, . .	sulcar endocœle.	*z.*, . . .	zooxanthellæ.
		s. ex., . .	sulcar exocœle.		

Edwardsia tecta, n. sp.

Figure.

1. Transverse section through the œsophageal region, $\frac{2}{A}$.

2. Transverse section through a mesentery, $\frac{2}{C}$.

Edwardsia timida, Quatrefages.

3. Transverse section through a mesentery, $\frac{2}{A}$.

Edwardsia beautempsii, Quatrefages.

4. Transverse section through a mesentery, $\frac{2}{C}$.

Edwardsia carnea, Gosse.

5. Transverse section through the parietal muscle of a mesentery, $\frac{3}{C}$.

6. Transverse section through a longitudinal retractor muscle, $\frac{3}{C}$.

Halcampa chrysanthellum (Peach).

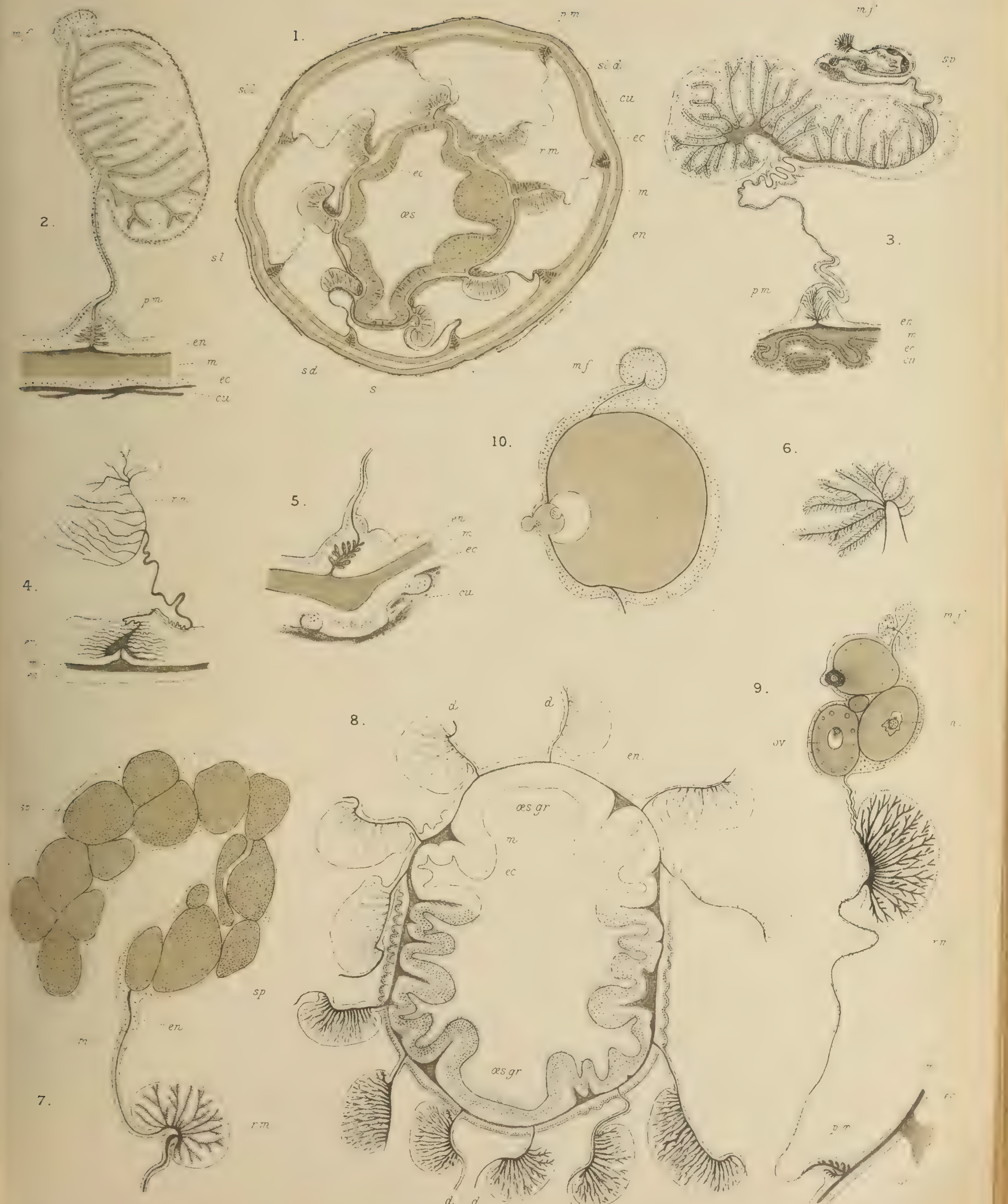
7. Transverse section through a fertile (male) mesentery, $\frac{2}{A}$.

Halcampa arenarea, Haddon.

8. Transverse section through the œsophagus, $\frac{2}{B}$.

9. Transverse section through a fertile (female) mesentery, $\frac{2}{B}$.

10. Section through an ovum, showing the formation of a polar-body while still within the mesentery, $\frac{2}{C}$.



Haddon del ad nat

F. Huth, Lith.r Ed.n

EXPLANATION OF PLATE XXXVII.

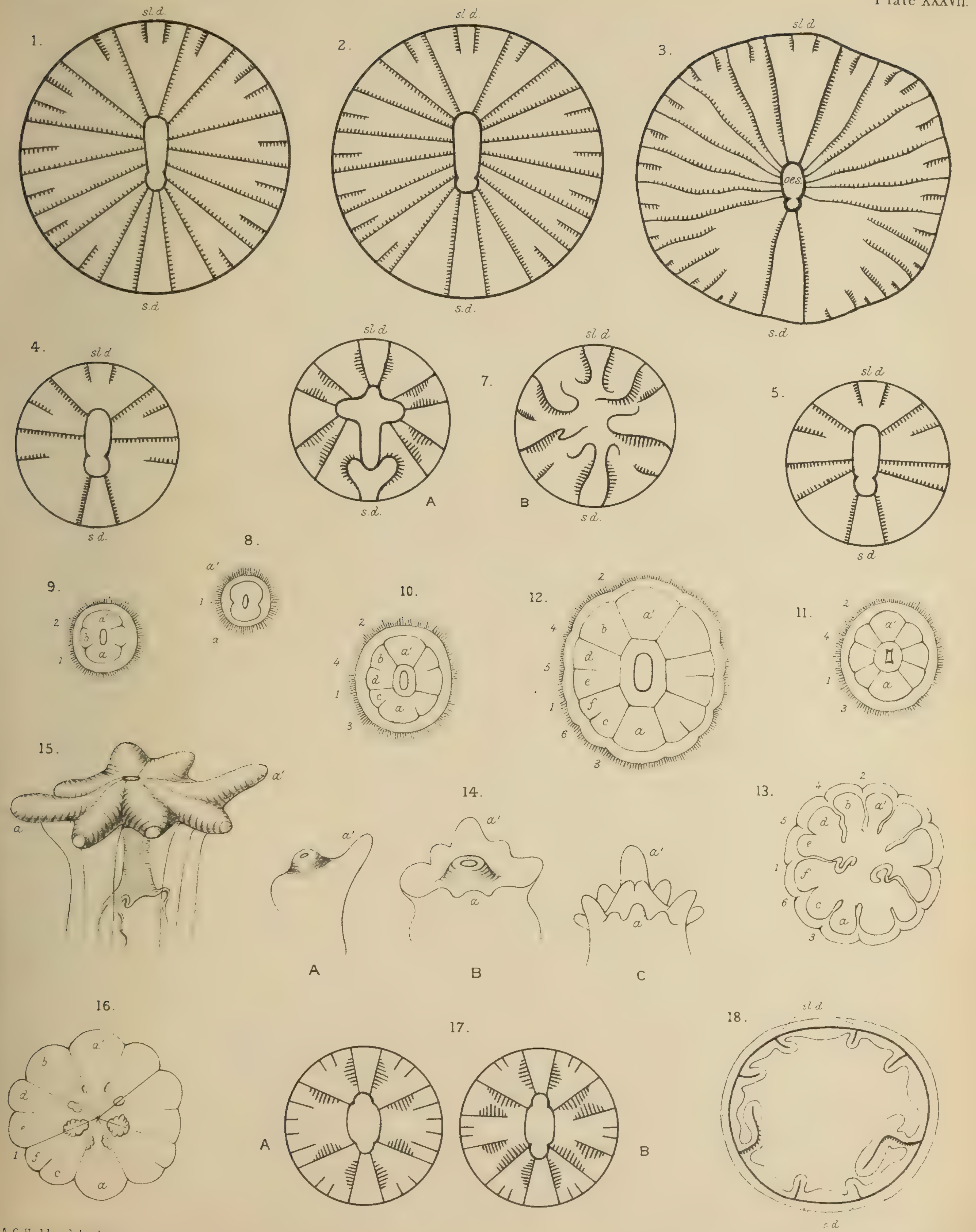
PLATE XXXVII.

LETTERING ADOPTED IN ALL THE FIGURES.

a.,	acontia.
ax. t.,	axial tentacle.
c. m.,	circular muscle.
c. m. en.,	circular muscles of endoderm.
cu.,	cuticle.
d.,	directive mesenteries.
ec.,	ectoderm.
en.,	endoderm.
g. s.,	grains of sand.
l. ex.,	lateral exocœle.
m.,	mesoglœa.
m. f.,	mesenterial filament.
n.,	nucleus.
œs.,	œsophagus.
œs. gr.,	œsophageal groove.
ov.,	ovum.
p. d.,	pedal disk.
p. m.,	parietal muscle.
r. m.,	retractor muscle.
sc.,	sucker.
s.,	sulcus.
s. en.,	sulcar endocœle.
s. ex.,	sulcar exocœle.
s. d.,	sulcar directive mesentery.
s. l. en.,	sulco-lateral endocœle.
sl.,	sulculus.
sl. d.,	sulcular directive mesentery.
sl. en.,	sulcular endocœle.
sl. ex.,	sulcular exocœle.
sl. l. en.,	sulculo-lateral endocœle.
s. l. m.,	sulco-lateral mesentery.
sl. l. m.,	sulculo-lateral mesentery.
sp.,	sperm-cell.
z.,	zooxanthellæ.

Figure.

1. Diagrammatic section through the œsophageal region of Zoanthus.
2. Diagrammatic section through the œsophageal region of Epizoanthus.
3. Diagrammatic section through the œsophageal region of a young Zoanthus, slightly modified from R. Hertwig (*i. e.* the retractor muscles of the mesenteries are added).
4. Diagram of a larval Zoanthus ("Microgrundform").
5. Diagram of a larval Epizoanthus ("Macrogrundform").
7. Larva of *Halcampa chrysanthellum*. *A*, diagrammatic transverse section through œsophageal region; *B*, similar section through digestive region.
8. Larva of *Actinia equina* (after Lacaze Duthiers), first appearance of mesenteries. *a*, Smaller chamber (sulcar endocœle); *a′*, larger chamber (sulcular endocœle); 1, first pair of mesenteries.
9. Larva of *Actinia equina* (after Lacaze Duthiers). Stage of four mesenteries. (Lettering as before) *b*, first lateral chamber (sulcular exocœle); 2, second pair of mesenteries.
10. Larva of *Actinia equina* (after Lacaze Duthiers). (Lettering as before) *c*, second lateral chamber (sulcar exocœle); *d*, third lateral chamber (sulculo-lateral endocœle); 3 and 4, third and fourth pairs of mesenteries.
11. Larva of *Actinia equina* (after Lacaze Duthiers). Octoradiate stage. (Lettering as before.)
12. Larva of *Actinia equina* (after Lacaze Duthiers). Later stage than fig. 11. (Lettering as before) *e*, fourth lateral chamber (lateral exocœle); *f*, fifth lateral chamber sulco-lateral endocœle); 5 and 6, fifth and sixth pairs of mesenteries.
13. Larva of *Actinia equina* (after Lacaze Duthiers). Optical section of same stage as last. (Lettering as before.) The mesenterial filaments have a size proportional to the order of their development.
14. Larva of *Actinia equina* (after Lacaze Duthiers). Three stages in the development of the tentacles—*A*, stage with only one tentacle; *B*, octoradiate stage; *C*, stage with twelve tentacles; *a*, sulcar; *a′*, sulcular extremities of axial line.
15. Larva of *Bunodes verrucosa* (after Lacaze Duthiers). Oral end of octoradiate stage. *a*, sulcar tentacle; *a′*, sulcular tentacle.
16. Larva of *Bunodes verrucosa* (after Lacaze Duthiers). Optical section of an early stage, with twelve chambers—*a*, sulcar endocœle; *a′*, sulcular endocœle; *b*, sulcular exocœle; *c*, sulcar exocœle; *d*, sulculo-lateral endocœle; *e*, lateral exocœle; *f*, sulco-lateral endocœle; 1, first pair of mesenteries developed with craspeda.
17. *Adamsia diaphana* (after O. and R. Hertwig). *A*, diagrammatic transverse section through the œsophageal region of a young form; *B*, similar section, through an older individual.
18. Diagrammatic transverse section through the digestive region of a larval *Cereus pedunculatus*.



A C Haddon del ad nat

F Huth, Lith^r Edin^r

ADDENDA ET CORRIGENDA.

Cypria serena (Koch) (p. 70).

Fossil.—Tertiary: English Crag (Jones, as *C. ovum*).
Page 73, line 6, for "*Cypris fuscata*" read "*Monoculus fuscatus.*"

Erpetocypris reptans (Baird) (p. 84).

Fossil.—Tertiary: English Crag.

Potamocypris fulva, Brady (p. 93).

Distribution.—Dr. Wilhelm Müller has lately sent us this species from Greifswald, Germany. This is the first time it had been found, we believe, on the Continent.
Fossil.—Post-tertiary: Scotland (Dalmuir).

Paracypris polita, G. O. Sars (p. 95).

Fossil.—Tertiary: Antwerp Crag.

Candona candida, Baird (p. 98).

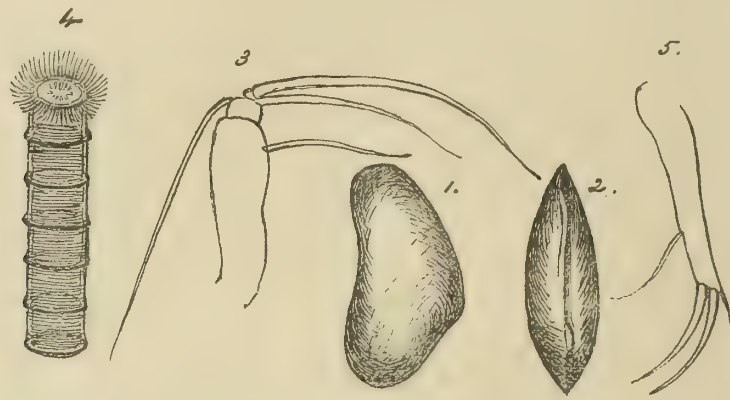
Fossil.—Post-tertiary: England, Scotland. Tertiary: English Crag.

Candona hyalina, Brady and Robertson (p. 104).

1870. *Candona hyalina*, Brady and Robertson, Ann. and Mag. Nat. Hist., ser. IV., vol. vi., p. 18; pl. ix., figs. 5–8; and pl. v., figs. 4–11.

Shell of the *male*, seen from the side, elongate, flexuous, highest behind the middle, height equal to half the length; anterior extremity narrow, rounded, but somewhat flattened; posterior broader and well rounded; dorsal margin forming a rounded gibbous prominence behind the middle, then sloping with a long, gentle curve to the front—much more steeply, and with a hollow curve, backwards; ventral margin deeply sinuated in the middle. Seen from above, the outline is much compressed, ovate, widest in the middle; extremities equal, and acutely pointed, width scarcely equal to one-third of the length; hinge margins flexuous, that of the left valve overlapping the right with a gentle curve in front of the middle, and with a very abrupt and short but strongly-marked curve near the posterior extremity. Shell very thin and translucent. Antennules slender, and very sparingly setiferous. Caudal rami bearing two long and nearly equal terminal claws, and one minute seta, also a long and slender lateral seta attached a little beyond the middle of the ramus. Verticillate sac destitute of radiating filaments, except on the apical whorl. Copulative organs extremely complex. Apical joint of the second foot bearing three very long and slender setæ but no hook, penultimate joint with a single seta of moderate length. Length of shell, 1·4 mm.

The single specimen on which the foregoing description is founded having been mislaid, we were unable, while engaged in the examination of the *Candonæ* for the purposes of this Memoir, to verify the original description,* and came to the conclusion that *C. hyalina* was probably only *C. fabæformis*, a species which, when *C. hyalina* was described, was very imperfectly known to us. But the dissection of the male type specimen of *C. hyalina* has since been found, and we have now no doubt whatever as to its specific distinctness. As to the specimens ascribed by Messrs. Brady and Robertson to the females of



Candona hyalina (*male*).

1. Shell, seen from left side. 2. The same, seen from above.
3. Extremity of second foot. 4. Verticillate sac (diagrammatic).
5. Caudal ramus.

this species, we are unable to express any decided opinion. The question needs to be considered afresh with the help of a larger series of specimens. The specimen here figured, which is the only one upon which we can pronounce certainly, was taken at Barton Broad, Norfolk. The other localities given by Brady and Robertson are, Whittlesea, Wroxham, and Ormesby Broads.

The drawing here given of the verticillate sac is quite diagrammatic, the specimen having been too much distorted in mounting to be represented, as it is now seen in the dissected mounting.

Ilyocypris gibba (Ramdohr) (p. 107).

Fossil.—Tertiary: English Crag.

Darwinula stevensoni, Brady and Robertson (p. 122).

Fossil.—Post-tertiary: England (Whittlesea).

Cythere (?) *semipunctata*, Brady (p. 130).

Fossil.—Post-tertiary: Scotland (Oban).

Cythere semilunaris = *Cythere amissa* (p. 136).

We find that *Cythere amissa* is a name already in use, having been employed by Prof. T. R. Jones for an Eocene Fossil (Geological Magazine, 1870, vol. vii., p. 156); we therefore substitute *C. semilunaris* as the name for the species which we have described.

* See p. 104.

Cythere gibbosa, Brady and Robertson (p. 136).

Fossil.—Post-tertiary : Ireland (Portrush).

Cythere convexa, Baird (p. 140).

Fossil.—Tertiary : English Crag.

Cythere limicola (Norman) (p. 142).

Fossil.—Tertiary : Antwerp Crag.

Cythere hoptonensis, Brady, Crosskey, and Robertson (p. 158).

Fossil.—Post-tertiary : England (Hopton Cliff).

Cythere concinna (Jones) (p. 162).

Fossil.—Tertiary : English Crag.

Cythere dawsoni, Brady (p. 166).

Fossil.—Tertiary : (?) Antwerp Crag.

Krithe bartonensis (Jones) (p. 179).

Fossil.—Tertiary : English Crag.

TABLE OF DISTRIBUTION OF THE "FRESH-WATER" OSTRACODA CONTAINED IN THIS MEMOIR.

Species.	England.	Scotland.	Ireland.	Norway.	Sweden.	Germany.	Belgium.	France.	Switzerland.	Bohemia.	Hungary.	Transylvania.	Russia.	Post-tertiary. Fossils.	Tertiary. Fossils.	Other Localities in which the Species have occurred.
CYPRIDIDÆ.																
CYPRIA.																
exsculpta (S. Fischer),	×	×	×	..	×	×	..	×	..	..	..	..	×	..	..	
ophthalmica (Jurine),	×	×	×	×	×	×	×	×	×	×	..	×	×	×	..	
lævis (O. F. Müller),	×	×	×	×	×	×	×	×	×	..	×	×	×	×	..	Finland, Denmark.
serena (Koch),	×	×	×	×	×	×	×	×	..	..	×	..	..	×	×	Tyrol.
joanna (Baird),	×	..	..	..	..	..	..	..	..	..	..	..	..	..	..	
CYCLOCYPRIS.																
globosa (G. O. Sars),	×	×	..	×	..	×	..	..	..	..	..	..	..	×	..	
SCOTTIA.																
browniana (Jones),	..	×	..	..	..	..	..	..	..	..	..	..	..	×	..	
CYPRIS.																
fuscata (Jurine),	×	×	×	×	×	×	×	×	×	×	×	×	×	..	..	Denmark (?), Tyrol, Italy.
incongruens, Ramdohr,	×	×	×	×	×	×	×	×	×	..	×	×	×	..	..	Finland, Sicily, Madeira, Egypt.
pubera, O. F. Müller,	×	×	×	×	×	×	×	×	×	..	×	×	×	..	..	Denmark, Finland, Tyrol, Italy.
virens (Jurine),	×	×	..	×	×	×	×	×	×	×	×	×	..	×	..	
elliptica, Baird,	×	..	..	..	×	..	..	..	..	..	..	..	×	..	..	
reticulata, Zaddach,	×	×	×	..	×	×	..	..	..	..	..	..	×	..	..	
obliqua, Brady,	×	×	..	..	..	..	..	×	..	..	..	..	..	..	..	
(?) gibbosa, Baird,	×	..	..	..	..	..	..	..	..	..	..	..	..	..	..	
prasina, Fischer,	×	×	×	..	×	..	..	×	..	..	..	..	..	×	..	Holland, Sicily,
cambrica, Brady and Robertson,	×	..	..	..	..	..	..	..	..	..	..	..	..	..	..	
ornata, O. F. Müller,	×	..	..	..	×	×	×	×	×	..	×	×	..	..	..	Denmark.
clavata, Baird,	×	..	..	..	×	×	..	..	..	..	..	..	..	..	..	
fischeri, Lilljeborg,	..	..	..	..	×	..	..	..	..	..	..	..	×	..	..	
trigonella, Brady,	×	..	..	..	..	..	..	..	..	..	..	..	..	..	..	
crassa, O. F. Müller,	..	..	..	..	×	..	..	..	..	..	..	..	×	..	..	
bispinosa, Lucas,	..	..	×	..	..	..	..	..	..	..	..	..	..	..	..	Guernsey, Egypt.
rubra (Jurine),	..	..	..	..	..	..	×	..	×	..	..	..	..	..	..	
quadripartita, Plateau,	..	..	..	..	..	..	×	..	..	..	..	..	..	..	..	
strausii, Plateau,	..	..	..	..	..	..	×	..	..	..	..	..	..	..	..	
ERPETOCYPRIS.																
reptans (Baird),	×	×	×	×	×	×	..	×	..	×	..	×	..	×	×	Tyrol, Sicily.
strigata (O. F. Müller),	×	×	..	×	×	×	..	..	..	..	×	..	×	..	..	Denmark.
fasciata (O. F. Müller),	..	..	..	×	×	×	..	..	..	..	×	..	..	..	..	Denmark, Tyrol.
serrata (Norman),	×	..	..	..	..	×	..	×	..	..	×	×	..	..	..	
tumefacta (Brady and Robertson),	×	×	..	×	..	..	..	..	..	..	..	..	..	..	..	
robertsoni, Brady and Norman,	..	×	..	..	..	..	..	..	..	..	..	..	..	..	..	
olivacea, Brady and Norman,	×	×	..	..	..	..	..	..	..	..	..	..	..	..	..	

Cypridopsis.																
vidua (O. F. Müller),	×	×	×	×	×	×	..	×	×	×	×	×	×	×	..	Denmark, Tyrol, Sicily.
aculeata (Lilljeborg),	×	×	×	..	×	..	..	..	..	..	..	×	..	..	..	Holland, Finland.
villosa (Jurine),	×	×	×	..	×	×	×	×	×	..	..	..	..	..	..	
newtoni, Brady and Robertson,	×	×	..	..	..	..	..	..	..	..	..	..	..	×	..	
variegata, Brady and Norman,	×	×	×	×	..	..	×	×	..	..	..	..	..	..	..	
picta (Straus),	..	..	..	×	..	..	..	×	..	..	..	..	..	..	..	
Potamocypris.																
fulva, Brady,	×	×	×	..	..	×	..	..	..	..	..	..	..	×	..	
Notodromas.																
monacha (O. F. Müller),	×	×	×	×	×	×	×	×	×	×	×	×	×	..	..	Denmark, Finland, Tyrol.
Cyprois.																
flava (Zaddach),	..	×	..	×	×	×	..	..	..	..	×	..	×	..	..	
Candona.																
candida (O. F. Müller),	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	Denmark, Holland.
elongata, Brady and Norman,	..	..	×	..	..	..	..	..	..	..	..	..	..	..	..	
lactea, Baird,	×	×	×	..	..	..	..	×	..	..	..	..	..	×	..	Holland.
pubescens (Koch),	×	×	×	×	×	×	..	×	..	..	..	×	×	×	..	
rostrata, Brady and Norman,	×	×	..	×	..	..	..	..	..	..	..	..	×	..	..	
kingsleii, Brady and Robertson,	×	×	×	..	..	..	..	..	..	..	..	..	..	..	..	
fabæformis (Fischer),	×	×	×	..	×	..	..	×	..	..	..	..	×	..	..	
hyalina, Brady and Robertson,	×	..	..	..	..	..	..	..	..	..	..	..	..	..	..	
acuminata (Fischer),	×	×	..	×	..	×	..	..	..	..	×	..	×	..	..	
euplectella, Robertson,	..	×	..	..	..	..	..	..	..	..	..	..	..	..	..	
parabolica (Koch),	..	..	..	..	..	×	..	..	..	..	..	..	..	..	..	
Ilyocypris.																
gibba (Ramdohr),	×	×	..	..	×	×	..	×	×	..	×	..	×	×	×	
DARWINULIDÆ.																
Darwinula.																
stevensoni, Brady and Robertson,	×	×	×	..	..	×	..	×	..	..	..	..	..	×	..	Holland.
CYTHERIDÆ.																
Metacypris.																
cordata, Brady and Robertson,	×	..	×	..	..	..	..	..	..	..	..	..	..	..	..	Holland.
Limnicythere.																
inopinata (Baird),	×	×	..	..	×	..	..	..	..	..	..	..	..	×	..	Holland.
relicta (Lilljeborg),	..	..	..	..	×	..	..	..	×	..	..	..	..	..	..	
sancti-patricii, Brady and Robertson,	×	×	×	..	..	..	..	..	..	..	..	..	..	×	..	
monstrifica (Norman),	×	..	..	..	..	..	..	..	..	..	..	..	..	×	..	
Cytheridea.																
lacustris (G. O. Sars),	×	×	×	×	×	..	..	..	..	..	..	..	..	×	..	

TABLE OF DISTRIBUTION OF THE "MARINE" OSTRACODA CONTAINED IN THIS MEMOIR.

Species.	Channel Isles.	England.	Scotland.	Ireland.	Madeiran Province.	S.-W. France.	Mediterranean.	Holland.	Norway.	Finmark.	Spitzbergen.	Iceland.	Greenland.	Atlantic (Abyssal).	1–15 faths.	15–100 faths.	100–500 faths.	500–3000 faths.	Post-tertiary. Fossils.	Tertiary. Fossils.	Other Localities in which the Species have been found.
AGLAIA.																					
complanata, Brady and Robertson,	..	..	..	×	..	..	..	..	..	..	..	..	..	..	×	..	..	..	..	..	
PARACYPRIS.																					
polita, G. O. Sars,	×	×	×	×	..	×	×	..	×	..	..	..	..	..	..	×	×	..	×	×	New Zealand.
PONTOCYPRIS.																					
mytiloides (Norman),	×	×	×	×	..	×	×	..	×	..	..	..	..	..	×	×	..	..	×	..	
hispida, G. O. Sars,	..	..	×	×	..	..	..	..	×	..	..	..	..	..	..	×	..	..	..	..	
acupunctata, Brady,	..	×	×	×	..	..	..	..	×	..	..	..	..	..	×	×	..	..	×	..	
trigonella, G. O. Sars,	×	×	×	×	..	..	×	..	×	×	..	..	..	..	×	×	..	..	×	..	Cape Verd and Bermudas.
ANCHISTROCHELES.																					
acerosa (Brady),	..	×	×	×	..	..	..	×	..	..	..	..	..	..	..	×	..	..	..	..	
ARGILLŒCIA.																					
cylindrica, G. O. Sars,	..	×	×	×	..	×	×	×	×	×	..	..	..	..	..	×	..	..	×	..	
BAIRDIA.																					
inflata, Norman,	×	×	×	×	..	×	..	..	×	×	..	..	..	..	..	×	..	..	×	..	
acanthigera, Brady,	×	×	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	? ×	..	Cape Verd.
subcircinata, Brady and Norman,	..	..	..	..	×	..	..	..	..	..	..	..	..	×	..	..	×	×	..	..	South Pacific (?).
folini, Brady,	..	..	..	..	×	..	..	..	..	..	..	..	..	..	..	..	..	×	..	..	
angulata, Brady,	..	..	..	..	..	..	..	..	..	..	..	..	..	×	..	..	×	..	..	..	South Atlantic, Straits of Magellan, Torres Strait.
simplex, Brady,	..	..	..	..	×	..	..	..	..	..	..	..	..	..	..	..	..	×	..	..	Off Heard Island.
victrix, Brady,	..	..	..	..	×	..	..	..	..	..	..	..	..	×	..	..	×	×	..	..	Kerguelen, Australia, &c.
abyssicola, Brady,	..	..	..	..	×	..	..	..	..	..	..	..	..	..	..	..	..	×	..	..	North Pacific.
crosskeyana, Brady,	..	..	..	..	..	×	×	..	..	..	..	..	..	..	..	×	×	..	..	..	Tongatubu, Honolulu, &c.
affinis, Brady,	..	..	..	..	×	..	..	..	..	..	..	..	..	..	..	..	..	×	..	..	
obtusata, G. O. Sars,	..	..	×	×	..	..	..	..	×	..	..	..	..	..	..	×	×	..	×	..	
hirsuta, Brady,	..	..	..	..	×	..	..	..	..	..	..	..	..	..	..	..	..	×	..	..	South Pacific.
complanata, Brady,	..	..	×	..	..	..	×	..	×	..	..	..	..	..	..	..	×	..	×	..	
MACROCYPRIS.																					
minna (Baird),	..	..	×	..	×	×	..	..	×	×	..	..	..	..	..	×	×	..	×	..	
angusta (G. O. Sars),	..	..	..	..	×	..	..	..	..	×	..	..	..	..	..	×	×	..	..	..	
siliquosa, Brady,	..	..	..	..	×	..	..	..	..	..	..	..	..	×	..	..	..	×	..	..	

B[illegible]																					
bosquetiana, Brady,	..	..	..	..	×	..	..	..	..	..	..	..	..	×	..	×	×	..	..	..	Prince Edward's Island, Bass Strait, &c.
Cythere.																					
lutea, Müller,	×	×	×	×	..	..	×	..	×	×	×	×	×	..	×	..	..	..	×	..	Gulf of St. Lawrence.
pellucida, Baird,	..	×	×	×	..	×	×	×	×	..	..	..	..	..	×	..	..	..	×	..	
confusa, Brady and Norman,	×	×	×	×	..	×	×	×	×	..	..	×	..	..	×	×	..	..	×	..	Gulf of St. Lawrence.
porcellanea, Brady,	..	×	×	×	..	..	..	×	×	..	..	×	..	..	×	..	..	..	×	..	
macallana, Brady,	..	×	×	×	..	..	×	..	..	..	..	..	..	..	..	×	..	..	×	..	
tenera, Brady,	..	×	×	×	..	×	×	×	×	..	..	..	..	..	×	×	..	..	×	..	Vigo Bay.
mamillata, Brady,	..	..	..	..	..	..	..	..	..	..	..	..	..	×	..	..	×	..	..	..	
semipunctata, Brady,	..	×	×	×	..	×	..	..	×	..	..	..	..	..	..	×	..	..	×	..	
badia, Norman,	×	×	×	×	..	..	×	..	..	..	..	..	..	..	×	..	..	..	..	..	
crispata, Brady,	..	×	×	×	..	..	×	..	×	..	..	..	..	..	×	×	..	..	×	..	Australia, Kong-Kong, &c.
cribrosa, Brady, Crosskey, and Robertson,	..	..	..	×	..	..	..	..	..	..	..	..	..	..	×	..	..	..	×	×	
teres, Brady,	..	×	..	..	..	×	..	..	..	..	..	..	..	..	×	..	..	..	..	..	
sulcifera, Brady,	..	..	..	×	×	..	..	..	..	..	..	..	..	×	..	..	..	×	..	..	
corpulenta, Brady and Norman,	..	..	..	..	..	..	..	..	×	..	..	..	..	..	..	..	×	..	..	..	
lamellifera, Brady and Norman,	..	..	..	..	..	..	..	..	..	..	..	..	..	×	..	..	..	×	..	..	
semilunaris, Brady and Norman,	..	..	..	..	..	×	..	..	..	..	..	..	..	..	..	×	..	..	..	..	
gibbosa, Brady and Robertson,	..	×	×	×	..	..	..	..	..	..	..	..	×	..	×	..	..	..	×	..	
rubida, Brady,	..	..	×	×	..	..	..	..	×	..	..	..	..	..	×	..	..	..	..	..	
oblonga, Brady,	..	×	..	..	..	×	×	..	×	..	..	..	..	..	×	×	..	..	..	..	
albomaculata, Baird,	×	×	×	×	..	×	×	..	×	..	..	..	..	..	×	×	..	..	×	..	Cape Verd, Vigo Bay.
leioderma, Norman.	..	..	×	..	..	..	..	..	×	..	..	×	×	..	..	..	×	..	×	..	Gulf of St. Lawrence.
robertsoni, Brady,	..	×	×	×	..	..	..	..	×	..	..	..	..	..	..	×	×	..	×	..	
convexa, Baird,	×	×	×	×	..	×	×	..	×	..	..	..	..	..	×	×	..	..	×	×	
speyeri, Brady,	..	..	..	..	..	×	×	..	..	..	..	..	..	..	..	×	×	×	..	..	Cape Verd, Ascension Is., &c.
marginata, Norman,	×	×	×	×	..	×	..	..	×	..	×	..	..	..	×	×	..	..	×	..	
jeffreysii, Brady,	×	×	..	×	..	..	..	..	..	..	..	..	..	..	..	×	..	..	×	..	
limicola, Norman,	..	×	×	×	..	..	..	..	×	×	..	..	×	..	..	×	..	..	×	×	
cuneiformis, Brady,	×	×	×	×	..	..	..	..	×	..	..	..	..	..	×	×	..	..	×	..	
navicula (Norman),	..	×	×	×	..	..	..	×	×	..	..	..	..	..	..	×	..	..	..	..	
globulifera, Brady,	..	..	..	×	..	..	..	..	×	..	×	..	×	..	..	×	..	..	×	..	
cluthæ, Brady, Crosskey, and Robertson,	..	..	×	×	..	..	..	..	..	..	..	..	×	..	×	×	..	..	×	..	
complexa, Brady,	..	..	×	..	..	..	..	..	×	..	..	..	..	..	..	×	..	..	..	..	
villosa (G. O. Sars),	×	×	×	×	..	..	..	×	×	..	..	×	×	..	×	×	..	..	×	..	
pulchella, Brady,	..	×	×	×	..	..	..	×	..	..	..	..	×	..	×	..	..	..	×	..	
borealis, Brady,	..	×	..	..	..	..	..	..	..	..	..	..	×	..	..	×	..	..	..	..	
fuscata, Brady,	..	×	..	..	..	..	..	×	..	..	..	..	..	..	×	..	..	..	..	..	
macchesneyi, Brady and Crosskey,	..	..	..	..	..	..	..	..	..	..	..	..	×	..	×	..	..	..	×	..	
septentrionalis, Brady,	..	..	..	..	..	..	..	..	..	..	..	..	×	..	..	×	..	..	..	..	
echinata (G. O. Sars),	..	..	..	×	×	..	..	..	×	×	..	..	..	×	..	×	×	×	..	..	N. & S. Pacific, S. Atlantic, &c.
acanthoderma, Brady,	..	..	..	×	..	..	×	..	..	..	..	..	..	×	..	..	×	×	×	..	Indian and Pacific Oceans, &c.
dictyon, Brady,	..	..	..	..	×	..	..	..	..	..	..	..	..	×	..	×	×	×	..	..	Indian, S. Atlantic, and Pacific Oceans, &c.
dasyderma, Brady,	..	..	..	×	..	..	..	..	..	..	..	..	..	×	..	..	×	×	×	..	
scabrocuneata, Brady,	..	..	..	×	..	×	..	..	..	..	..	..	..	×	..	×	..	×	..	..	Bass Strait, New Zealand, [Japan.
scaberrima, Brady,	..	..	..	..	×	..	..	..	..	..	..	..	..	..	..	..	..	×	..	..	
trispicata, Brady and Norman,	..	..	..	..	..	×	..	..	..	..	..	..	..	..	..	..	..	..	..	..	
latimarginata, Speyer,	..	?	×	..	..	..	..	..	×	×	×	..	×	×	..	×	×	×	×	×	
lepida, Brady and Norman,	..	..	..	..	..	..	..	..	..	..	..	..	..	×	..	..	..	×	..	..	
hoptonensis, Brady, Crosskey, and Robertson,	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	×	..	Portugal.
crenulata (G. O. Sars),	..	..	×	..	..	..	..	..	×	..	..	..	×	..	..	×	×	..	..	..	
quadridentata, Baird,	..	×	×	×	..	..	×	..	×	..	..	..	..	..	×	×	..	..	×	..	
emaciata, Brady,	..	×	×	×	..	×	×	..	..	..	..	..	..	×	..	×	×	..	×	..	
runcinata, Baird,	..	×	..	..	..	×	×	..	..	..	..	..	..	×	×	×	×	×	..	..	
tuberculata (G. O. Sars),	×	×	×	×	..	×	×	..	×	×	×	×	×	..	×	×	..	..	×	..	Gulf of St. Lawrence.
milne-edwardsii, Brady and Norman,	..	..	..	..	×	..	..	..	..	..	..	..	..	..	..	..	..	×	..	..	
bradii, De Folin,	..	..	..	..	..	×	..	..	..	..	..	..	..	..	..	..	..	..	..	..	
concinna, G. O. Sars,	..	×	×	×	..	..	..	..	×	×	..	×	×	..	×	×	×	..	×	×	

TABLE OF DISTRIBUTION OF THE "MARINE" OSTRACODA CONTAINED IN THIS MEMOIR.

Species.	Channel Isles.	England.	Scotland.	Ireland.	Madeiran Province.	S.-W. France.	Mediterranean.	Holland.	Norway.	Finmark.	Spitzbergen.	Iceland.	Greenland.	Atlantic (Abyssal).	1–15 faths.	15–100 faths.	100–500 faths.	500–3000 faths.	Post-tertiary. Fossils.	Tertiary. Fossil.	Other Localities in which the Species have occurred.
CYTHERE—*continued*.																					
dubia, Brady,	..	..	×	..	..	..	..	..	..	..	..	..	..	..	..	..	×	..	..	..	
emarginata (G. O. Sars),	..	..	×	..	..	..	..	..	×	×	×	×	×	..	×	×	..	..	×	..	
finmarchica (G. O. Sars),	×	×	×	×	..	×	..	..	×	×	..	..	×	..	×	×	..	..	×	..	Cape Verd.
costata, Brady,	..	..	×	..	..	..	..	..	..	..	..	..	×	..	×	×	..	..	×	..	Gulf of St. Lawrence.
angulata (G. O. Sars),	..	×	×	×	..	..	..	..	×	×	..	×	×	..	×	×	..	..	×	..	
mucronata (G. O. Sars),	..	..	×	..	..	..	..	..	×	×	..	..	..	..	..	..	×	..	..	×	
canadensis, Brady,	..	..	..	..	..	..	..	..	..	..	..	..	×	..	..	×	..	..	..	..	Gulf of St. Lawrence.
dawsoni, Brady,	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	×	?	Gulf of St. Lawrence.
audax, Brady and Norman,	..	..	..	..	..	..	..	..	..	..	..	..	..	×	..	..	..	×	..	..	
mirabilis, Brady,	..	..	×	..	..	..	..	..	..	..	×	..	..	..	..	..	..	..	×	..	
dunelmensis (Norman),	..	×	×	×	..	..	..	..	×	×	×	×	×	..	×	×	×	..	×	..	
antiquata (Baird),	..	×	×	×	..	×	×	..	..	..	..	..	..	..	×	×	..	..	×	..	
whitei (Baird),	..	×	×	×	..	..	×	..	..	..	..	..	..	..	..	×	..	..	×	..	Gulf of St. Lawrence.
jonesii (Baird),	..	×	×	×	..	×	×	..	×	..	×	..	..	..	..	..	..	..	×	×	
CYTHERIDEA.																					
elongata (Brady),	×	×	×	×	..	×	×	×	..	..	×	..	..	..	×	×	..	..	×	..	Gulf of St. Lawrence.
papillosa, Bosquet,	..	×	×	×	..	..	..	..	×	×	×	×	×	..	..	×	×	..	×	..	Gulf of St. Lawrence.
punctillata, Brady,	..	×	×	×	..	..	×	..	×	×	×	×	×	..	..	×	×	..	×	×	
torosa (Jones),	×	×	×	×	..	×	×	..	×	..	..	..	..	..	×	..	..	..	×	×	In freshwater, Sedgefield, Co. [Durham, &c.
castanea, Brady,	..	..	..	..	..	×	×	..	..	..	..	..	..	..	..	..	..	..	..	..	
subflavescens, Brady,	..	..	×	×	..	..	..	..	..	..	..	..	..	..	..	×	..	..	..	..	
fascis, Brady and Norman,	..	..	..	..	..	..	..	..	..	..	..	..	×	..	..	..	×	..	..	..	
sorbyana, Jones,	..	×	×	×	..	..	..	..	×	×	×	..	×	..	..	×	×	..	×	×	
EUCYTHERE.																					
declivis (Norman),	×	×	×	×	..	×	×	..	×	×	..	..	..	..	×	×	×	..	×	..	Gulf of St. Lawrence.
KRITHE.																					
bartonensis (Jones),	..	×	×	×	..	×	..	..	×	×	..	..	..	..	×	×	×	×	×	×	Kerguelen, Ki Islands.
producta, Brady,	..	..	×	×	×	..	..	..	..	..	..	..	..	×	..	..	×	×	..	..	Prince Edward's Island, Aus- [tralia, &c.
angusta, Brady and Norman,	..	..	..	..	..	..	..	..	×	..	..	..	..	..	..	..	×	..	..	..	
reniformis (Brady),	..	..	..	..	..	×	×	..	..	..	..	..	..	..	..	..	×	..	..	..	
glacialis, Brady, Crosskey, and Robertson,	..	..	..	..	..	..	..	..	..	..	..	..	..	×	..	..	..	×	×	..	
LOXOCONCHA.																					
impressa (Baird),	×	×	×	×	..	×	×	..	×	×	..	..	..	..	×	×	..	..	×	..	Sweden, Baltic.
guttata (Norman),	..	×	×	×	..	×	×	..	×	..	..	..	..	..	×	×	×	..	×	..	Vigo Bay.
[illegible]	×	×	×	×	[illegible]	×	×	×	..	..	..	×	..	..	×	..	..	..	×	..	Denmark, Sweden, Baltic, Fin- [land.

[illegible],	×	×	×	×	..	×	×	..	×	×	..	×	..	..	..	×	..	..	×	×	
fragilis, G. O. Sars,	..	×	×	×	..	..	..	..	×	×	..	..	..	..	..	×	×	..	×	..	
XESTOLEBERIS.																					
aurantia (Baird),	×	×	×	×	..	..	..	×	×	×	..	..	×	..	×	..	..	..	×	..	Sweden.
depressa, G. O. Sars,	×	×	×	×	..	×	×	..	×	×	×	..	×	..	×	×	..	..	×	×	Gulf of St. Lawrence, Kerguelen.
labiata, Brady and Robertson,	..	×	..	..	..	..	×	..	..	..	..	..	..	..	×	..	..	..	×	..	
margaritea (Brady),	..	..	..	..	..	×	×	..	..	..	..	..	..	..	×	×	..	..	..	..	Off Booby Island.
CYTHERURA.																					
gibba (Müller),	..	×	×	×	..	..	..	×	×	..	..	..	..	..	×	..	..	..	×	..	Sweden, Denmark, Baltic, Finland.
cornuta, Brady,	..	×	×	×	..	..	×	..	..	..	..	..	..	..	×	×	..	..	×	×	
affinis, G. O. Sars,	..	..	..	..	..	..	..	..	×	..	..	..	..	..	..	×	×	..	..	..	
sella, G. O. Sars,	×	×	×	×	..	×	×	×	×	..	..	..	..	..	×	×	×	..	×	..	
acuticostata, G. O. Sars,	×	×	×	×	..	..	×	..	×	..	..	..	..	..	×	×	..	..	×	..	
striata, G. O. Sars,	×	×	×	×	..	..	×	×	×	..	..	..	..	..	×	×	..	..	×	..	
exserta, Brady and Norman,	..	..	..	..	..	..	..	..	×	..	..	..	..	..	..	..	×	..	..	..	
angulata, Brady,	..	×	×	×	..	..	..	×	×	..	..	..	..	..	×	×	..	..	×	..	
atra, G. O. Sars,	..	..	..	..	..	..	..	..	..	×	..	..	..	..	×	..	..	..	×	..	
undata, G. O. Sars,	..	×	×	×	..	..	..	×	×	×	×	..	×	..	×	×	×	..	×	..	Gulf of St. Lawrence.
producta, Brady,	..	×	×	×	..	..	..	×	×	..	..	..	..	..	..	×	..	..	×	..	
groenlandica, Brady and Norman,	..	..	..	..	..	..	..	..	..	..	..	..	×	..	×	×	..	..	..	..	
nigrescens (Baird),	×	×	×	×	..	×	..	×	×	..	..	..	..	..	×	..	..	..	×	..	
simplex, Brady and Norman,	..	×	×	×	..	..	..	..	..	..	..	..	..	..	×	..	..	..	..	..	
concentrica, Brady, Crosskey, and Robertson,	..	×	×	..	..	..	..	..	×	..	×	..	×	..	×	×	..	..	×	..	
similis, G. O. Sars,	..	×	×	×	..	..	..	..	×	×	..	..	..	..	×	×	×	..	×	..	
rudis, Brady,	..	..	..	..	..	..	..	..	..	..	×	..	×	..	×	×	×	..	×	..	
fulva, Brady and Robertson,	..	×	×	×	..	×	..	..	..	..	..	..	..	..	×	×	..	..	..	..	
clathrata, G. O. Sars,	..	×	×	×	..	..	..	..	..	×	×	..	×	..	..	×	..	..	×	..	
cellulosa (Norman),	×	×	×	×	..	×	×	×	×	..	..	..	..	..	×	×	×	..	×	..	
CYTHEROPTERON.																					
latissimum (Norman),	..	×	×	×	..	..	..	×	×	×	×	..	×	..	×	×	..	..	×	×	
nodosum, Brady,	..	×	×	..	..	×	..	..	×	..	..	..	..	..	×	×	..	..	×	..	Gulf of St. Lawrence.
pyramidale, Brady,	..	..	..	..	..	..	..	..	×	..	×	..	×	..	..	×	..	..	..	..	
inflatum, Brady, Crosskey, and Robertson,	..	..	×	..	..	..	..	..	×	..	×	..	×	×	..	×	×	..	×	..	
subcircinatum, G. O. Sars,	..	..	..	..	..	..	..	..	×	..	..	..	..	..	×	..	..	..	..	..	
læve, Brady and Norman,	..	..	..	..	..	..	..	..	..	..	..	..	..	×	..	..	..	×	..	..	
punctatum, Brady,	..	×	×	×	..	×	..	..	×	..	..	..	..	..	..	×	×	..	..	..	
intermedium, Brady,	..	..	..	..	..	..	..	..	..	..	..	..	..	..	×	..	..	..	..	×	Spain.
crassipinnatum, Brady and Norman,	..	..	..	×	..	..	..	..	..	..	..	..	..	..	..	×	..	..	..	..	
hamatum, G. O. Sars,	..	..	..	..	..	..	..	..	×	×	..	..	×	..	..	×	×	..	×	..	
arcuatum, Brady, Crosskey, and Robertson,	..	..	..	..	..	..	..	..	..	..	..	..	×	..	..	×	..	..	×	..	
alatum, G. O. Sars,	..	..	×	×	..	..	..	..	×	..	..	..	..	..	..	×	×	..	..	..	
mucronalatum, Brady,	..	..	..	..	×	..	..	..	..	..	..	..	..	×	..	..	..	×	..	..	Off Japan, near Patagonia.
montrosiense, Brady, Crosskey, and Robertson	..	..	..	×	..	..	..	..	..	..	×	..	×	..	×	×	..	..	×	..	
angulatum, Brady and Robertson,	..	×	×	×	..	..	..	..	..	..	..	..	..	..	..	×	..	..	×	..	
depressum, Brady and Norman,	..	×	..	×	..	..	..	×	..	..	..	..	..	..	×	×	..	..	..	..	
testudo, G. O. Sars,	..	..	..	..	..	..	..	..	×	×	..	..	..	..	..	..	×	..	..	..	
humile, Brady and Norman,	..	..	×	..	..	..	..	..	..	..	..	..	..	..	×	..	..	..	..	..	Spain.
BYTHOCYTHERE.																					
constricta, G. O. Sars,	×	×	×	×	..	×	..	..	×	..	×	..	..	..	..	×	×	..	×	×	
turgida, G. O. Sars,	..	×	×	×	..	..	..	..	×	..	×	..	..	..	×	..	..	..	..	..	Gulf of St. Lawrence.
insignis, G. O. Sars,	..	..	..	..	..	..	..	..	..	×	..	..	..	..	..	..	×	..	..	..	

TABLE OF DISTRIBUTION OF THE "MARINE" OSTRACODA CONTAINED IN THIS MEMOIR.

Species.	Channel Isles.	England.	Scotland.	Ireland.	Madeiran Province.	S.-W. France.	Mediterranean.	Holland.	Norway.	Finmark.	Spitzbergen.	Iceland.	Greenland.	Atlantic (Abyssal).	1–15 faths.	15–100 faths.	100–500 faths.	500–3000 faths.	Post-tertiary. Fossil.	Tertiary. Fossil.	Other Localities in which the Species have occurred.
Bythocythere—*continued.*																					
bicristata, Brady and Norman,	. .	. .	×	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	×	. .	. .	. .	. .	
recta (Brady),	. .	×	×	×	. .	×	. .	. .	. .	. .	. .	. .	. .	. .	×	. .	×	. .	×	. .	
dromedaria, G. O. Sars,	. .	. .	. .	. .	. .	. .	. .	. .	×	. .	. .	. .	. .	. .	. .	×	. .	. .	. .	. .	
simplex (Norman),	. .	×	×	×	. .	. .	. .	. .	×	×	. .	. .	×	. .	×	×	. .	. .	×	. .	
recurva, Brady and Norman,	. .	. .	. .	. .	. .	×	. .	. .	. .	. .	. .	. .	. .	. .	. .	×	. .	. .	. .	. .	
Pseudocythere.																					
caudata, G. O. Sars,	×	×	×	×	. .	×	×	. .	×	. .	. .	. .	. .	. .	×	×	×	×	×	. .	Off Kerguelen, off Prince Edward's Island.
Sclerochilus.																					
contortus (Norman),	×	×	×	×	. .	×	×	×	×	×	×	. .	×	. .	×	×	×	. .	. .	. .	
Cytherideis.																					
subulata, Brady,	×	×	×	×	. .	×	×	. .	. .	. .	. .	. .	. .	. .	. .	×	. .	. .	. .	×	Cape Verd Islands.
foveolata, Brady,	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	×	. .	. .	×	. .	. .	. .	. .	Gulf of St. Lawrence.
Cytherois.																					
fischeri (G. O. Sars),	. .	×	×	×	. .	. .	×	. .	×	. .	. .	. .	. .	. .	×	×	. .	. .	×	. .	Pomerania.
PARADOXOSTOMATIDÆ.																					
Paradoxostoma.																					
variabile (Baird),	×	×	×	×	. .	. .	. .	×	×	×	×	. .	×	. .	×	×	. .	. .	×	. .	Vigo Bay.
ensiforme, Brady,	×	×	×	×	. .	×	×	×	×	. .	. .	. .	. .	. .	×	×	. .	. .	×	×	Kerguelen Island
abbreviatum, G. O. Sars,	. .	×	×	×	. .	×	. .	×	×	. .	. .	. .	. .	. .	×	×	×	. .	×	. .	
obliquum, G. O. Sars,	×	×	×	×	. .	. .	. .	. .	. .	×	. .	. .	. .	. .	×	. .	. .	. .	. .	. .	
normani, Brady,	×	×	×	×	. .	×	. .	. .	. .	. .	. .	. .	. .	. .	×	×	×	. .	. .	. .	
pulchellum, G. O. Sars,	×	×	×	×	. .	. .	. .	. .	×	. .	. .	. .	. .	. .	×	. .	. .	. .	. .	. .	

vitreum, G. O. Sars.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible], Brady and Norman,	×	..	..	..	..	..	..	..	..	..	..	..	..	..	×	..	..	..	..	..
arcuatum, G. O. Sars.	..	×	×	×	..	..	..	..	..	..	..	..	..	..	×	..	..	..	×	..
orchadense, Brady and Robertson,	..	×	×	×	..	×	..	..	×	..	..	..	..	..	..	×	×	..	..	..
hodgei, Brady,	..	×	×	×	..	..	..	..	..	..	..	..	..	..	..	×	..	..	..	..
rostratum, G. O. Sars,	..	..	..	..	..	..	..	..	..	×	..	..	..	..	..	..	..	..	..	..
productum, Brady and Norman,	..	..	..	..	..	..	..	..	×	..	..	..	..	..	..	×	×	..	..	..
flexuosum, Brady,	×	×	×	×	..	×	..	×	×	..	..	..	×	..	×	×	×	..	..	..
MACHÆRINA.																				
tenuissima (Norman),	..	×	×	×	..	..	..	..	..	..	..	..	..	..	..	×	..	..	..	..
amygdaloides (Brady),	..	..	×	..	..	×	×	..	..	..	..	..	..	..	×	×	×	..	..	..

SUMMARY OF THE DISTRIBUTION OF THE OSTRACODA (SECTION PODOCOPA) CONTAINED IN THIS MEMOIR.

SPECIES.	Total described.	Total British.	Channel Islands.	England.	Scotland.	Ireland.	Madeiran Province.	Mediterranean.	Russia.	Transylvania.	Hungary.	Bohemia.	Switzerland.	Western France.	Belgium.	Germany.	Holland.	Sweden.	Norway.	Finmark.	Spitzbergen.	Iceland.	Greenland.	Atlantic (Abyssal).	1–15 faths.	15–100 faths.	100–500 faths.	500–3000 faths.	Post-tertiary. Fossils.	Tertiary. Fossils.
Freshwater Species,	61	51	1	45	39	27	—	—	20	14	16	7	14	24	15	27	7	30	22	—	—	—	—	—	—	—	—	—	20	4
Marine Species,	188	134	41	100	114	108	17	49	—	—	—	—	—	57	—	—	30	—	94	39	26	14	43	23	90	116	62	27	99	30
Total,	249	185	42	145	153	135	17	49	20	14	16	7	14	81	15	27	37	30	116	39	26	14	43	23	90	116	62	27	119	34

The second and sixth columns contain some species which are found off the West of Ireland in depths down to 1500 fathoms.

WORKS AND PAPERS CONSULTED IN THE PREPARATION OF THIS MONOGRAPH.

Baird (W.):

Natural History of the British Entomostraca (Mag. Zool. and Botany, vol. ii., 1838, p. 132).

Description of some new species and genera of British Entomostraca (Ann. and Mag. Nat. Hist., ser. i., vol. xvii., 1846, p. 410).

Note on the genus *Cypridina, M. Edw.*, with description of two new species (Ann. and Mag. Nat. Hist., ser. ii., vol. i., 1848, p. 21).

Natural History of the British Entomostraca (Ray Society), 1850.

Description of several new species of Entomostraca (Proc. Zool. Soc., London, vol. xviii., 1850, p. 254).

Monograph of the family *Apodidæ*, and description of two new species of *Cypris* (Proc. Zool. Soc., London, vol. xx., 1852. p. 1).

Some new species of *Cypridina* (Ann. and Mag. Nat. Hist., ser. iii., vol. vi., 1860, p. 139 ; and Proc. Zool. Soc., London, vol. xxviii, 1860, p. 200).

Bosquet J.):

Description des Entomostracés fossiles des terrains tertiaires de la France et de la Belgique, Bruxelles, 1850.

Brady (G. S.)

Species of Ostracoda new to Britain (Ann. and Mag. Nat. Hist., ser. iii., vol. xiii., 1864, p. 59).

Undescribed Fossil Entomostraca from the Brick-earth of the Nar (Ann. and Mag. Nat. Hist., ser. iii., vol. xvi., 1865).

Report on Ostracoda dredged amongst the Hebrides (Brit. Assoc. Report, 1866, p. 208).

New and imperfectly-known species of Marine Ostracoda (Trans. Zool. Soc., vol. v., 1866, p. 359).

Entomostraca (Intellectual Observer, 1862, p. 446).

Synopsis of recent British Ostracoda (Intellectual Observer, 1867, p. 110).

Crustacean Fauna of the Salt Marshes of Northumberland and Durham (Nat. Hist. Trans. Northumb. and Durham, vol. iii., 1868, p. 1).

Monograph of recent British Ostracoda (Trans. Lin. Soc., vol. xxvi., 1868, p. 353).

Contributions to the Study of the Entomostraca (Ann. and Mag. Nat. Hist., ser. iv., vol. ii., 1868, pp. 30, 178, 220 ; vol. iii., 1869, p. 45 ; and vol. iv., 1870, p. 450).

Descriptions of Ostracoda (Berchon, De Folin, and Perier, Les Fonds de la Mer, vols. i., ii., and iv., 1867–86).

Notes on the Ostracoda (Nares' Narrative of a Voyage to the Polar Sea, 1875–6, in H. M. S. S. "Alert" and "Discovery," 1878, p. 253.)

Notes on Entomostraca taken chiefly in the Northumberland and Durham district (Nat. Hist. Trans. Northumberland and Durham, vol. iii., 1870, p. 361).

BRADY (G. S.)—*continued:*

Review of the Cypridinidæ of the European Seas (Proc. Zool. Soc., 1871, p. 289).
Monograph of the Ostracoda of the Antwerp Crag (Trans. Zool. Soc., vol. x., 1878, p. 379).
Report Voyage of H. M. S. "Challenger"—Ostracoda, 1880.
Notes on Entomostraca collected by Mr. A. Haly in Ceylon (Lin. Soc. Journal, vol. xix., 1885).
Notes on Freshwater Entomostraca from South Australia (Proc. Zool. Soc., 1886).
Notes on Entomostraca (Fifth Annual Report Fishery Board of Scotland, Appendix F, 1887, p. 328).

BRADY (G. S.) AND CROSSKEY (W. H.):

On Fossil Ostracoda from the Post-tertiary Deposits of Canada and New England (Geological Magazine, vol. viii., 1871).

BRADY, CROSSKEY, AND ROBERTSON:

Monograph of the Post-tertiary Entomostraca of Scotland, and parts of England and Ireland (Palæontographical Society, 1874).

BRADY (G. S.) AND ROBERTSON (D.):

Notes on a Week's Dredging in the West of Ireland (Ann. and Mag. Nat. Hist., ser. IV., vol. iii., 1869, p. 353).
Ostracoda and Foraminifera of Tidal Rivers (Ann. and Mag. Nat. Hist., ser. IV., vol. vi., 1870, p. 1).
On the Distribution of British Ostracoda (Ann. and Mag. Nat. Hist., ser. IV., vol. ix., 1872, p. 48).
Ostracoda taken among the Scilly Islands, and on the Anatomy of *Darwinella stevensoni* (Ann. and Mag. Nat. Hist., ser. IV., vol. xiii., 1874, p. 114).
Report on Dredging off the Coasts of Durham and North Yorkshire (British Association Report, 1875, p. 185).

CARUS (J. V.):

Prodromus Faunæ Mediterraneæ. Arthropoda, 1885.

CROSSKEY AND ROBERTSON:

Notes on the Post-tertiary Geology of Norway (Phil. Soc., Glasgow, 1868).

CLAUS C.):

Ueber die Organisation der Cypridinen (Zeits. f. wiss. Zool., vol. xv., 1865, p. 143).
Zur näheren Kenntniss der Jugendformen von Cypris ovum (Zeits. f. wiss. Zool., xv., 1865, p. 391).
Ueber die Geschlechts differenzen von Halocypris (Zeits. f. wiss. Zool., xv., 1865).
Beiträge zur Kenntniss der Ostracoden (Schrift. der Gesells. z. Beförd. d. gesam. Naturwis. zu Marburg, Bd. ix., 1868, p. 151).
Neue Beobachtungen über Cypridinen (Zeits. f. wiss. Zool., XXIII., 1873, p. 211).
Bemerkungen über marine Ostracoden aus den familien der Cypridinen und Halocypriden (Arbeit. Zool. Inst. Wien und Zool. Stat. Trieste, t. VIII., Heft 1, 1888, pp. 149–154, Wien).
Die Gattungen und Arten der Halocypriden, 1874.

COSTA (O. G. and A.):

Fauna del Regno di Napoli. Crostacei.

Daday (E.):

Catalogus Crustaceorum Faunæ Transylvaniæ, 1884.

Dahl (Friederich):

Die Cytheriden der westlichen Ostsee (Zoologisch Jahrbuch, Bd. iii., Abtheilung fur Systematik, 1888).

Dana (J. D.):

Crustacea of the United States Exploring Expedition, 1855.

De Saussure (H.):

Mémoire sur divers Crustacés nouveaux des Antilles et du Mexique (Mem. de Soc. de Physique et d'Histoire Naturelle de Genève, 1858).

Desmarest (A. G.):

Considérations Générales sur la Classe des Crustacés (Paris, 1825).

Egger (J. G.):

Die Ostrakoden der Miocän-Schichten bei Ortenburg (Stuttgart, 1858).

Fischer (S.):

Über die in der Umgegend von St. Petersburg vorkommenden Crustaceen aus den Ordnung der Branchiopoden und Entomostraceen (Mém. des Sav. Etrangers., vii., 1847).

Abhandlung über das Genus Cypris (Mém. des Sav. Etrangers., vii., 1851).

Beitrag zur Kenntniss der Ostracoden (Abhandl. der mathemat.-physik. classe der Königlich-Bayerischen Akad. der Wissenschaft., vii., 1855, pt. 3).

Fischer (Dr. Paul):

Crustacés Ostracodes Marins des Côtes du Sud-Ouest de la France, 1877.

Folin (Marquis De):

Faune lacustre de l'ancien Lac d'Ossegor, 1879.

Frìc, A.):

Die Krustenthiere Böhmens, 1872.

Garbini:

Contrib. all 'Anatomia ed alla Istologia delle Cypridinae (Boll. Soc. Entom. Ital, xix.).

Heller (C.):

Untersuchungen über die Crustaceen Tirols, 1870.

Jones (T. R):

Monograph of the Tertiary Entomostraca of England (Palæont. Soc. 1856).

Notes on the Tertiary Entomostraca of England (Geological Magazine, vol. vii., 1870).

On some Fossil Ostracoda from Colorado (Geological Magazine, Decade ii., vol. iii., 1886)

JONES (T. R.) AND SHERBORN C. D.):

Further Notes on the Tertiary Entomostraca of England, &c. (Geological Magazine, Decade III., vol. iv., 1887).

JURINE (L.):

Histoire des Monocles, qui se trouvent aux environs de Genève, 1820.

KING (R. L.):

On Australian Entomostraca (Proc. Roy. Soc. Van Diemen's Land, vol. iii., pt. 1, 1855).

KOCH (C. L.):

Deutschlands Crustaceen, Myriapoden und Arachniden, Heft. 10, 1837; H. 11, 1837; H. 12, 1837; H. 21, 1838; H. 36, 1841.

KORSCHAGIN (A. N.):

Fauna of the neighbourhood of Moscow, Entomostraca-Malacostraca, 1887, 4to (in Russian).

LILLJEBORG (W.):

De Crustaceis ex ordinibus tribus Cladocera, Ostracoda et Copepoda in Scania occurrentibus, 1853.

Beskrifning ofver tva örter Crustaceen af ordningarna Ostracoda och Copepoda (Ofvers. af K. Vet. Akad. Forhand, 1862, p. 391).

Collection of chiefly Freshwater Crustacea from Sweden (International Fisheries Exhibition, London, 1883. Sweden Special Catalogue, p. 140).

De under Svenska vetenskapliga expeditionen till Spetsbergen, 1872–3, derstädes samlade Hafs-Entomostraceen (Kongl. Vetenskaps-Akad Förhand, xxxii., No. IV., p. 3, 1874).

LUBBOCK (J.):

On the Freshwater Entomostraca of South America (Trans. Entom. Soc., vol. iii., N. S., pt. IV., 1855).

On some Entomostraca collected by Dr. Sutherland in the Atlantic Ocean (Trans. Entom. Soc. vol. iv., N. S., pt. II., 1856).

On some Oceanic Entomostraca collected by Capt. Toynbee (Trans. Lin. Soc., vol. xxiii., p. 173, 1862).

MALCOMSON (S. M.):

Recent Ostracoda of Belfast Lough (Proc. Belfast Nat. Field Club, 1884–5, p. 259).

MONIEZ (R.):

List des Copépodes, Ostracodes, Cladocères, et quelques autres Crustacés recueilles a Lille en 1886 (Bull. Soc, Zool. de France, xii., 1887).

Note sur des Ostracodes, Cladocères et Hydrachnides observés en Normandie (Bull. Soc. d'Etudes Scient. de Paris, 1887).

MÜLLER (FRITZ):

Bemerkungen über Cypridina (Jenaischen Zeitschrift, v., Heft. 2, 1870, p. 255).

Descripção do Elpidium bromeliarum, crustaceo da familia dos Cytherideos (Archiv. d. Mus. Nacional. Rio de Janeiro, iv., 1879, p. 27).

Müller (O. F.):

Zoologiæ Danicæ Prodromus, 1776.
Entomostraca, 1785.

Müller (Wilhelm):

Zur näharen Kenntniss der Cytheriden (Archiv. für Naturgesch., 1884, p. 1).
Beitrag zur Kenntniss der Fortpflanzung und der Geschlechtsverhältnisse der Ostracoden (Zeitsch, f. d. gesamm. Naturwiss., 1880, p. 21).
Über die Function der Antennendrüse der Cytheriden (Zeitsch. f. gesamm. Naturwiss., 1880. p. 213).

Nordquist (Osc.):

Beitrag zur Kenntniss der inneren männlichen Geschlechtsorgane der Cypriden.

Norman (A. M.):

Contributions to British Carcinology (Ann. and Mag. Nat. Hist., ser. iii., vol. viii., 1861).
Species of Ostracoda new to Britain (Ann. and Mag. Nat. Hist., ser iii., vol. ix., 1862).
Reports Deep-sea Dredging, Coast of Northumberland and Durham—Crustacea (Nat. Hist. Trans. Northumberland and Durham, vol. i., 1865).
Report of Committee for Exploring Coasts of the Hebrides (Brit. Assoc. Report, 1866, p. 198).
Last Report on Dredging among the Shetland Isles (Brit. Assoc. Report, 1868, p. 248).
Report "Valorous" Expedition (Proc. Roy. Soc., No. 173, 1876, p. 202).

Orley (S.):

Über die Entomostraken-Fauna von Budapest (Természetrajzi Füzetek, x., 1886, pp. 7 and 98).

Pavesi (P.):

Altra serie di recheche e Studi sulla Fauna pelagica dei Laghi Italiani Padova, 1883.

Plateau (F.):

Recherches sur les Crustacés d'eau douce de Belgique (Mem. Couronnés et Mem. des Savants Etrangers, xxxiv., 1868).

Ramdohr (K. A.):

Beiträge zur Naturgeschichte einiger deutschen Monoculus-arten, Halle, 1805.

Reuss (A. E.):

Die fossilen Entomostraceen des osterreichischen Tertiarbeckens (Naturwiss. Abhandlungen, iii., 1847, p. 41).

Rochebrune (A. T.):

Observations sur la Cypris fusca (Act. Soc. Lin. de Bordeaux, xxiv., 1861, p. 77).

Robertson (David):

Notes on the Ostracoda and Foraminifera of the Firth of Clyde (Trans. Geol. Soc., Glasgow, vol. v., pt. i., p. 112, 1874).
Notes on a Raised Beach at Cumbrae (Trans. Geol. Soc., Glasgow, 1875).
Notes on Cypris lævis and its habit of perforating the leaves of Victoria regia (Proc. Nat. Soc., Glasgow, vol. ii., 1875, p. 7).

Post-tertiary Deposit by Tunnel at Arkleston, near Paisley (Trans. Geol. Soc., Glasgow, 1876, p. 292).

Garnoch Water Post-tertiary Deposit (Trans. Geol. Soc. Glasgow, 1876, p. 281).

Post-tertiary Deposit at Misk-Pit and Kilwinning (Trans. Geol. Soc., Glasgow, 1877, p. 297).

Notes on the Fauna and Flora of the west of Scotland, p. 38, 1876.

Post-tertiary Beds of Garvel Park, Greenock (Trans. Geol. Soc.,Glasgow, 1883, p. 1).

Fauna of Scotland, with special reference to Clydesdale and the western districts; Fresh and Brackish water Ostracoda. Glasgow, 1880.

SACCARDO (PIETRO ANDREA):

Cenni Storico-naturali intorno agli animaletti Entomostracei, &c. Treviso, 1864.

SARS (G. O.):

Om en i Sommeren 1862 fortagen Zoologisk Reise. Christiania, 1863.

Oversigt af Norges marine Ostracoder, 1865.

Nye Dybvandscrustaceer fra Lofoten (Vidensk.-Selsk. Forhand, 1869, p. 170).

Undersögelser over Christianiafjordens Dybvandsfauna, 1869.

Undersögelser over Hardangerfjordens Fauna. I., Crustacea (Vidensk.-Selks. Forhand, 1871, p 278).

Nye Bidrag til Kundskaben om Middelhavets Invertebratfauna. iv., Ostracoda Mediterranea (Archiv. for Mathem. og Naturvidenskab, 1887).

SARS (MICHAEL):

Om de i Norge forekommende fossile dyrelivningen fra Quartærperioden. Christiana, 1865.

SCHWARZ (C. G.):

Ueber die sogenannte "Schleimdrüse" der männlichen Cypriden (Berichten der Natur. f. Gesells. zu Freiburg, Bd. III., 1888, p. 5).

SEGUENZA (G.):

Le Formazioni Terziarie nella provincia di Reggio (Calabria), 1880.

Il Quaternario di Rizzolo. ii., Gli Ostracodi (Il. Naturalista Siciliano. Anno III., 1883).

SPEYER (OSCAR):

Die Ostracoden der Casseler Tertiarbildungen. Cassel., 1863.

STIMPSON (W.):

Synopsis of the Marine Invertebrata of Grand Manan (Smithsonian Contributions, 1853).

STRAUS (H. E.):

Mémoire sur les Cypris (Mém. du Museum, vol. vii., 1821).

STUHLMAN (F.):

Beiträge zur Anatomie der inneren männlichen Geschlechtsorgane und Spermatogenese der Cypriden (Zeits. f. wissensch. Zoologie, xliv., 1887, p. 536; and, Zoologischen Institut. zu Freiburg, I. B., 1886).

TERQUEM (M. O.):

Les Foraminifères et les Entomostracés-Ostracodes du Pliocène supérieur de l'Ile de Rhodes (Mém de la Soc. Géol. de France, sér. III., vol. i., 1878).

Thomson (G. M.):

New Zealand Entomostraca (Trans. New Zealand Institute, vol. xi., 1878).

Toth (Alex.):

Die in neuester Zeit zu Pest-Ofen gefundenen Schalenkrebse und ihre anatomischen Verhältnisse (Verhdlgn. d. Zool.-bot. Ges. Wien., xiii., 1863, p. 47).

Vernet (H.):

Acanthopus, un nouveau genre d'Ostracodes. (Forel, Matériaux pour servir a l'étude de la Faune profonde du Lac Leman ive. Série, 1879, p. 408.)

Weismann (A.):

Parthenogenese, b. d. Ostracoden (Zool. Anzeig., vol. iii., 1880, p. 82).

Woodward (H.):

A Catalogue of the British Fossil Crustacea. British Museum, 1887.

Zaddach (E. G.):

Synopseos Crustaceorum Prussicorum Prodromus, 1844.

Zenker (W.):

Anatomisch-systematische Studien über die Krebsthiere. Berlin, 1854.

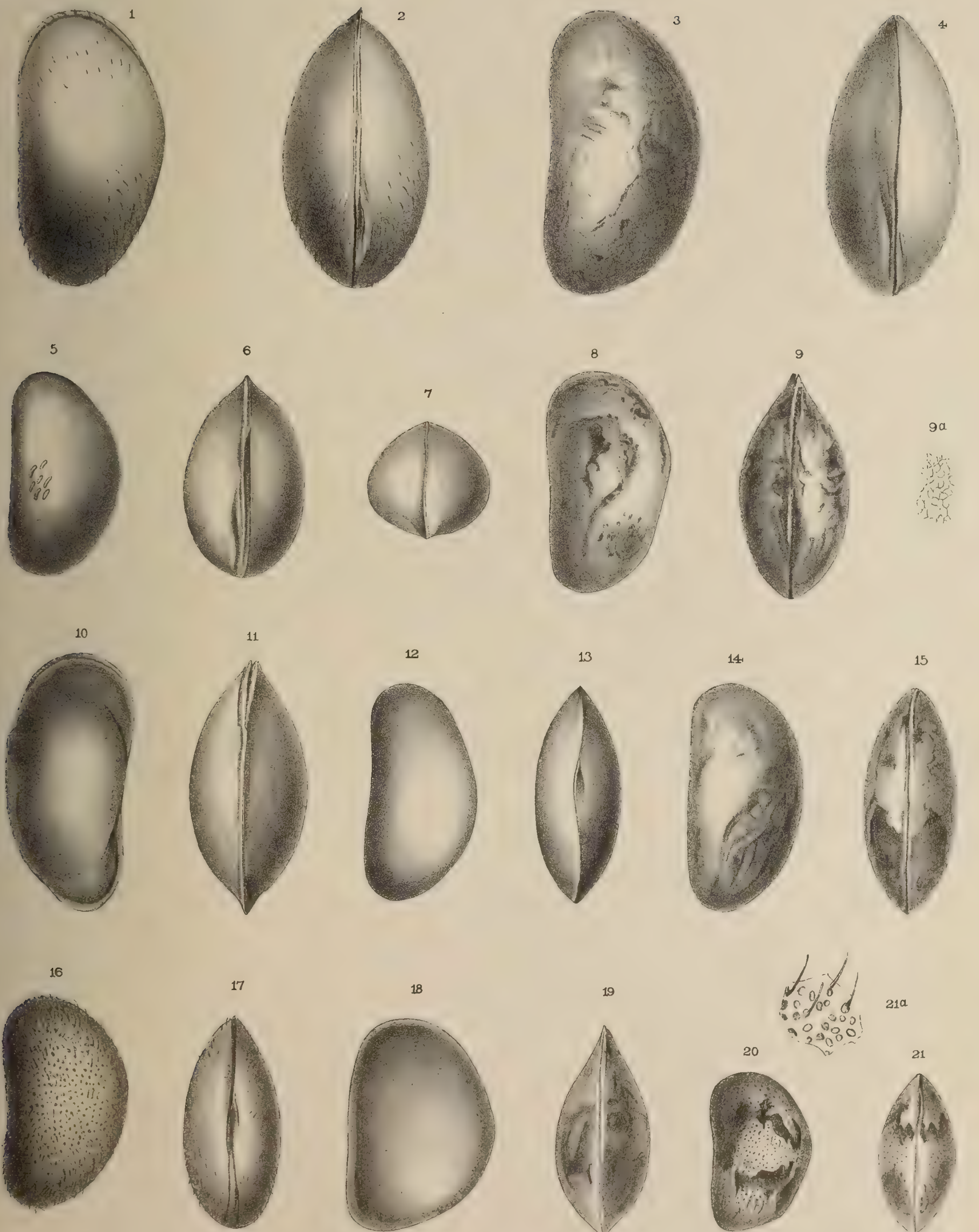
INDEX.

Note.—More Synonyms (in italics) are given in this Index than it was thought necessary to introduce into the body of the work. The pages referred to under such a name contains the species of which such additional name is the Synonym.

EXPLANATION OF PLATE VIII.

PLATE VIII.

Figure.		
1.	Cypris affinis, female, seen from left side, . . .	× 40
2.	,, ,, ,, ,, above, . . .	,,
3.	,, olivacea, ,, ,, left side, . . .	,,
4.	,, ,, ,, ,, above, . . .	,,
5.	,, tumefacta, female, seen from left side, . . .	× 40
6.	,, ,, ,, ,, above, . . .	,,
7.	,, ,, ,, end view, ...	,,
8.	,, ornata, female, seen from left side, . . .	× 20
9.	,, ,, ,, ,, above, . . .	,,
9*a*.	,, ,, portion of shell-surface (reflected light), .	× 50
10.	,, dromedaria, female, seen from right side, . .	× 22
11.	,, ,, ,, ,, above, . .	,,
12.	,, cambrica, female, seen from left side, . . .	× 60
13.	,, ,, ,, ,, below, . . .	,,
14.	Erpetocypris strigata, female, seen from left side, . .	× 16
15.	,, ,, ,, ,, above, . .	,,
16.	Cypridopsis newtoni, female, seen from left side, . .	× 50
17.	,, ,, ,, ,, below, . .	,,
18.	Cyprois flava, female, seen from left side, . . .	× 22
19.	,, ,, ,, ,, above, . . .	,,
20.	Cypridopsis variegata, female, seen from left side, . .	× 60
21.	,, ,, ,, ,, above, . .	,,
21*a*.	,, ,, shell structure (transmitted light), .	× 200



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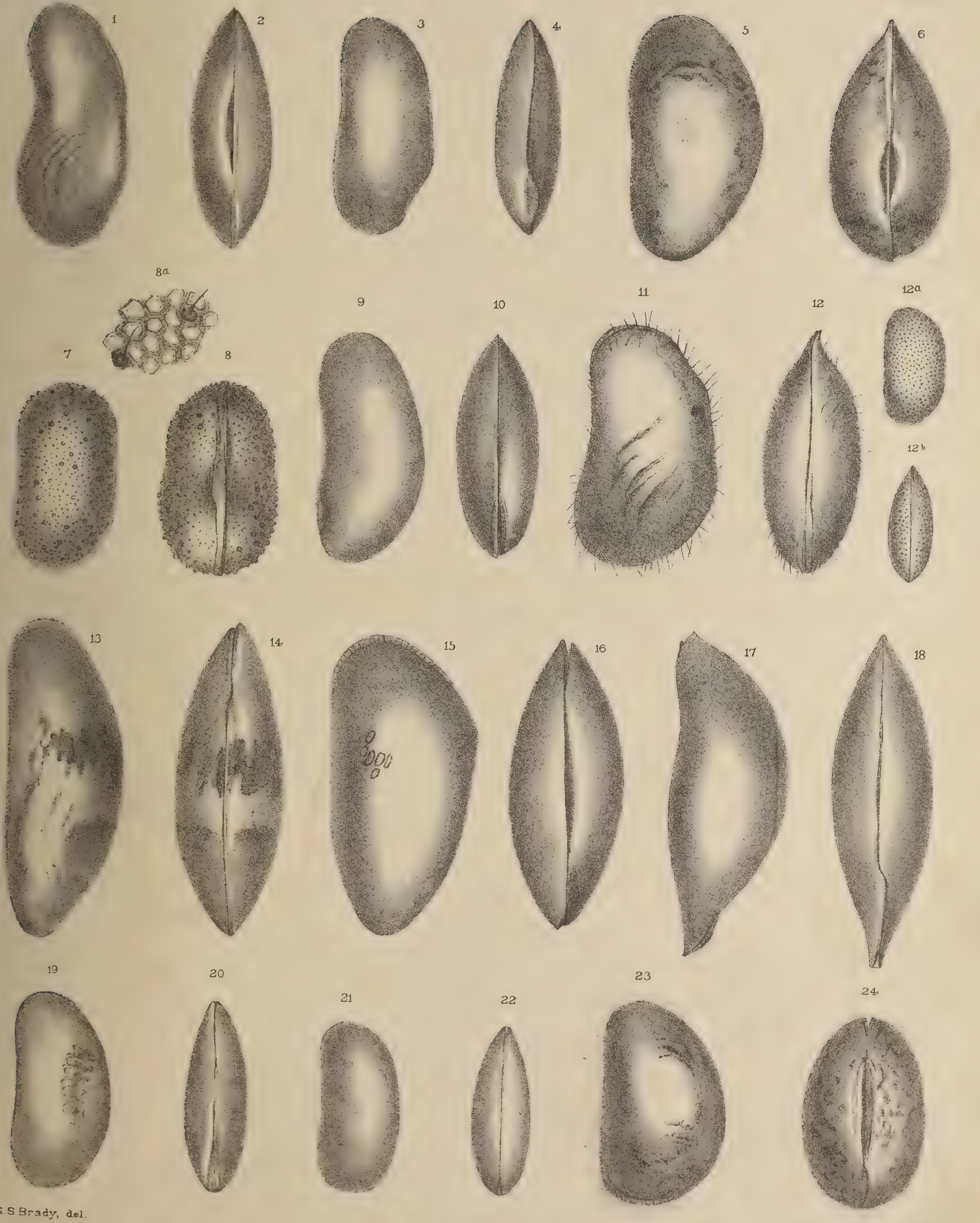
EXPLANATION OF PLATE IX.

PLATE IX.

Figure.		
1.	Candona fabæformis, male, seen from left side, . .	× 40
2.	,, ,, ,, ,, above, . .	,,
3.	,, ,, female, seen from left side, . .	,,
4.	,, ,, ,, ,, above, . .	,,
5.	Cypris hirsuta, female, seen from left side, . . .	,,
6.	,, ,, ,, ,, above, . . .	,,
7.	Candona euplectella, seen from left side, . . .	× 50
8.	,, ,, ,, above, . . .	,,
8*a*.	,, ,, shell structure, ...	× 210
9.	,, acuminata, female, seen from left side, . .	× 40
10.	,, ,, ,, ,, above, . .	,,
11.	,, rostrata, male, ,, left side, . .	,,
12.	,, ,, ,, ,, above, . .	,,
12*a*, *b*.	,, ,, junr., ...	,,
13.	Erpetocypris fasciata, female, ,, left side, . .	,,
14.	,, ,, ,, ,, above, . .	,,
15.	Cypris clavata, seen from left side, ...	× 24
16.	,, ,, ,, above, ...	,,
17.	Macrocypris angusta, seen from left side, . . .	× 40
18.	,, ,, ,, above, . . .	,,
19.	Candona kingsleii, male, seen from left side, . . .	× 40
20.	,, ,, ,, ,, above, . . .	,,
21.	,, ,, female, ,, left side, . . .	,,
22.	,, ,, ,, ,, above, . . .	,,
23.	Scottia browniana, female, seen from left side, . .	× 50
24.	,, ,, ,, ,, above, . .	,,

Plate IX.



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EXPLANATION OF PLATE X.

PLATE X.

Figure.		
1.	Candona candida, *var.* claviformis, male, seen from left side,	× 36
2.	,, ,, ,, ,, ,, above, .	,,
3.	Cypris fischeri, female, seen from left side, . . .	× 23
4.	,, ,, ,, ,, above, . . .	,,
5.	Candona acuminata, seen from left side, . . .	× 40
6.	,, ,, ,, above, . . .	,,
7.	Darwinula stevensoni, female, seen from left side, . .	× 40
8.	,, ,, ,, ,, above, . .	,,
9.	,, ,, ,, ,, below, . .	,,
10.	,, ,, ,, ,, front, . .	,,
11.	,, ,, male, ,, left side, . .	,,
12.	,, ,, ,, ,, above, . .	,,
13.	,, ,, lucid spots more highly magnified.	
14.	Candona candida, *var.* tumida, male, seen from left side, .	× 36
15.	,, ,, ,, ,, ,, above, .	,,
16.	,, ,, ,, female, ,, left side, .	,,
17.	,, ,, ,, ,, ,, above, .	,,
18.	Candona candida, *var.*, female, seen from left side (Ackworth),	× 36
19.	,, ,, ,, ,, above, . .	,,
20.	,, ,, male, ,, left side (Chester Rd.),	,,
21.	,, ,, ,, ,, above, . .	,,
22.	,, ,, female, ,, left side (Chester Rd.),	,,
23.	,, ,, ,, ,, above, . .	,,
24.	,, elongata, ,, ,, left side, . .	,,
25.	,, ,, ,, ,, above, . . .	,,
26.	,, ,, male, ,, left side, . .	,,
27.	,, ,, ,, ,, above, . .	,,
28.	Argilloecia cylindrica, seen from left side, . . .	× 80
29.	,, ,, ,, above, ...	,,
30.	Cypridopsis picta, female, seen from right side, . .	× 210
31.	,, ,, ,, ,, above, . . .	,,

Plate X.

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EXPLANATION OF PLATE XI.

PLATE XI.

Cypria exsculpta (*female*).

Figure.

1. Antennule.
2. Antenna.
3. Mandible and palp.
4. Caudal ramus.

4*a*. Portion of shell of young.

Cypria ophthalmica (*male*).

5. Second pair of maxillæ.
6. Caudal ramus.
7. Verticillate sac.
8. The same, viewed endwise.
9. Copulative organs.

Cyclocypris globosa (*male*).

10. Antennule.
11. Antenna.
12. Second maxilla, left side.
13. ,, ,, right side.
14. Foot of first pair.
15. ,, second pair.
16. Caudal ramus.
17. Verticillate sac.
18. Copulative organs.

Scottia browniana (*male*).

19. Antenna.
20. Mandible and palp.
21. Second maxilla.
22. Last joint of second foot.
23. Caudal ramus.

23*a*. Claw of the same, more highly magnified.

24. Verticillate sac.
25. Copulative organs.

[All the figures highly magnified.]

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EXPLANATION OF PLATE XII.

PLATE XII.

Figure.

1. Erpetocypris fasciata, end of caudal ramus.
2. Cypris fischeri, caudal ramus.
3. ,, fuscata, shell showing (*a*) outer, and (*b*) inner, pigmented layer.
4. ,, ,, caudal ramus.
5. ,, affinis, portion of shell.
6. ,, ,, ,, ,, (young).
7. ,, ,, caudal ramus.
8. ,, incongruens, portion of shell.
9. ,, ,, caudal ramus.
10. ,, obliqua, portion of shell.
11. Erpetocypris strigata, portion of shell (young).
12. Cypris hirsuta, ,, ,, ,,

Cyprois flava.

13. Antenna.
14. Mandible and palp.
15. Second maxilla of female.
16. ,, ,, male (right side).
17. ,, ,, ,, (prehensile portion of left side).
18. Extremity of second foot.
19. Verticillate sac of male.
20. Copulative organs of male.
21. Portion of shell.

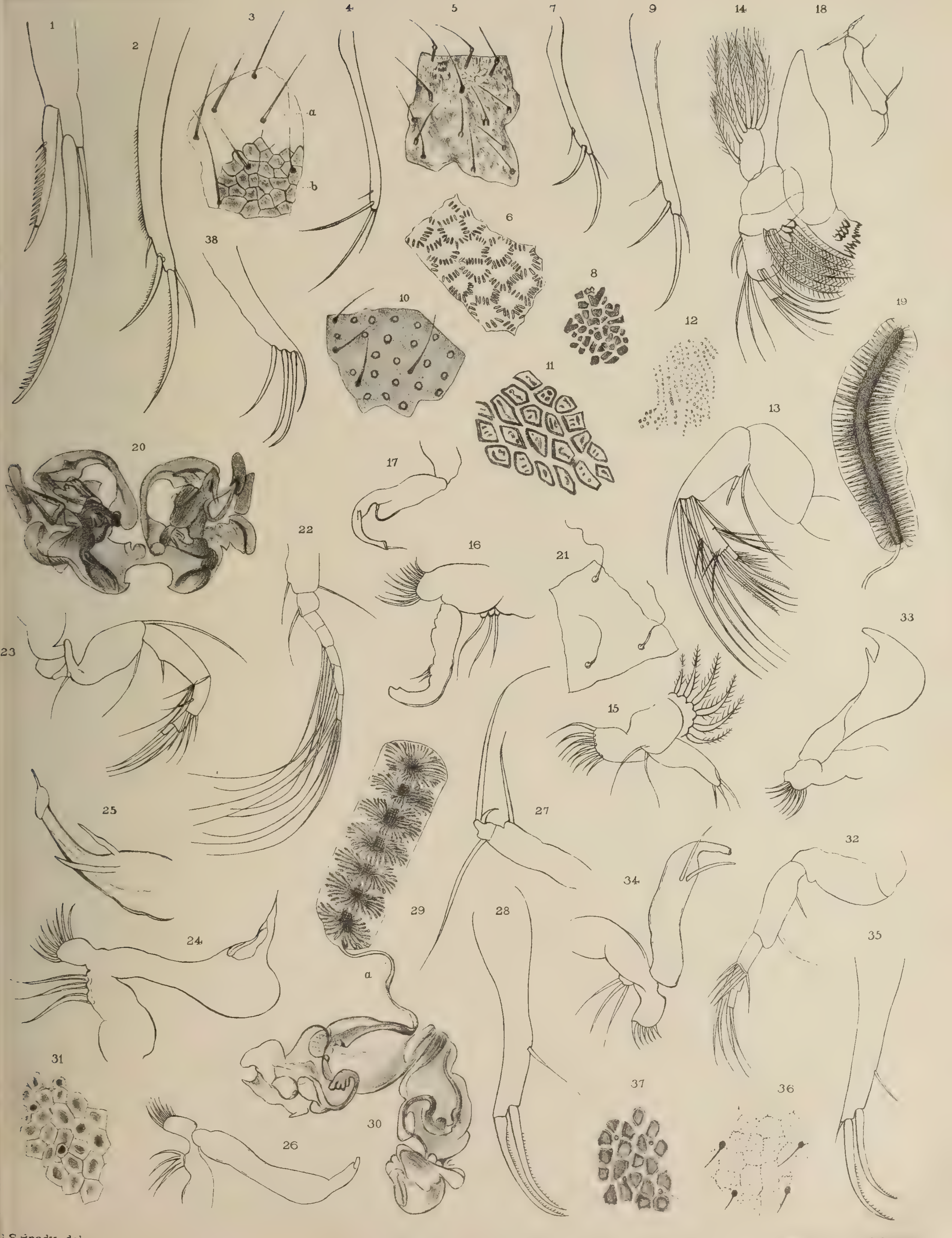
Candona rostrata.

22. Antennule.
23. Antenna.
24. Second maxilla of male.
25. Extremity of same seen obliquely (right side).
26. ,, ,, ,, (left side).
27. Extremity of second foot.
28. Caudal ramus.
29. Verticillate sac of male; (*a*) vas deferens.
30. Copulative organs of male.
31. Portion of shell (young).

Candona pubescens.

32. Antenna.
33. Second maxilla of male (right side).
34. ,, ,, ,, (left side).
35. Caudal ramus.
36. Portion of shell of adult.
37. Portion of shell of young.
38. Caudal ramus.

[The figures are all highly magnified, and those of shell structure are as viewed by transmitted light.]



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EXPLANATION OF PLATE XIII.

PLATE XIII.

Darwinula stevensoni.

Figure.	
1.	Antennule.
2.	Antenna.
3.	Mandible and palp.
4.	First maxilla.
5.	Second maxilla and palp.
6.	Foot of first pair.
7.	,, second pair.
8.	Extremity of abdomen.
9.	Copulative organ of male.

Metacypris cordata.

10.	Antennule.
11.	Antenna.
12.	Mandible and palp.
13.	Maxilla.
14.	Foot of first pair.
15.	,, second pair.
16.	,, third ,,
17.	Copulative organ of male.

Erpetocypris tumefacta.

18. Antenna.

Candona kingsleii.

19. Mandible of male.

Bairdia complanata.

20.	Antennule.
21.	Antenna.
22.	Mandible.
23.	Maxilla.
24.	First foot.
25.	Second foot.
26.	Caudal ramus.

Erpetocypris reptans.

27. Antenna.

Candona parabolica.

28.	Animal seen from left side, magnified.
29.	,, ,, above, ,,
30.	,, ,, natural size (after Koch).

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EXPLANATION OF PLATE XIV.

PLATE XIV.

Cyclocypris globosa.

Figure.		
1.	Shell of male, seen from left side, .	× 50
2.	,, ,, ,, above, .	,,

Metacypris cordata.

3.	Shell of female, seen from left side, .	× 84
4.	,, ,, ,, below, .	,,
5.	,, ,, ,, front, .	,,
6.	,, male, ,, left side, .	,,
7.	,, ,, ,, above, .	,,
8.	Right valve of female, seen from inside,	,,
9.	Left ,, ,, ,, ,,	,,
10.	Hinge margins, seen from above, .	,,
11.	Ventral margins, seen from below, .	,,
12.	Posterior margins, seen from behind, .	,,

Cythere pellucida.

13.	Shell of female, seen from left side, .	× 40
14.	,, ,, ,, above, .	,,
15.	,, male, ,, left side, .	,,

Cythere confusa.

16.	Shell of female, seen from left side, .	× 40
17.	,, ,, ,, above, .	,,
18.	,, male, ,, left side, .	,,

Cythere macallana.

19.	Shell of female, seen from left side, .	× 60
20.	,, ,, ,, above, .	,,
21.	,, male, ,, left side, .	,,

Cythere porcellanea.

Figure.		
22.	Shell of female, seen from left side, .	× 60
23.	,, ,, ,, above, .	,,
24.	,, male, ,, left side, .	,,

Cythere cluthæ.

25.	Shell, seen from left side, . . .	× 100
26.	,, ,, above, . . .	,,
27.	,, ,, below, . . .	,,

Aglaia complanata.

28.	Shell, seen from left side, . . .	× 60
29.	,, ,, above, . . .	,,

Cythere gibbosa.

30.	Shell, seen from left side, . . .	× 80
31.	,, ,, above, . . .	,,

Cythere robertsoni.

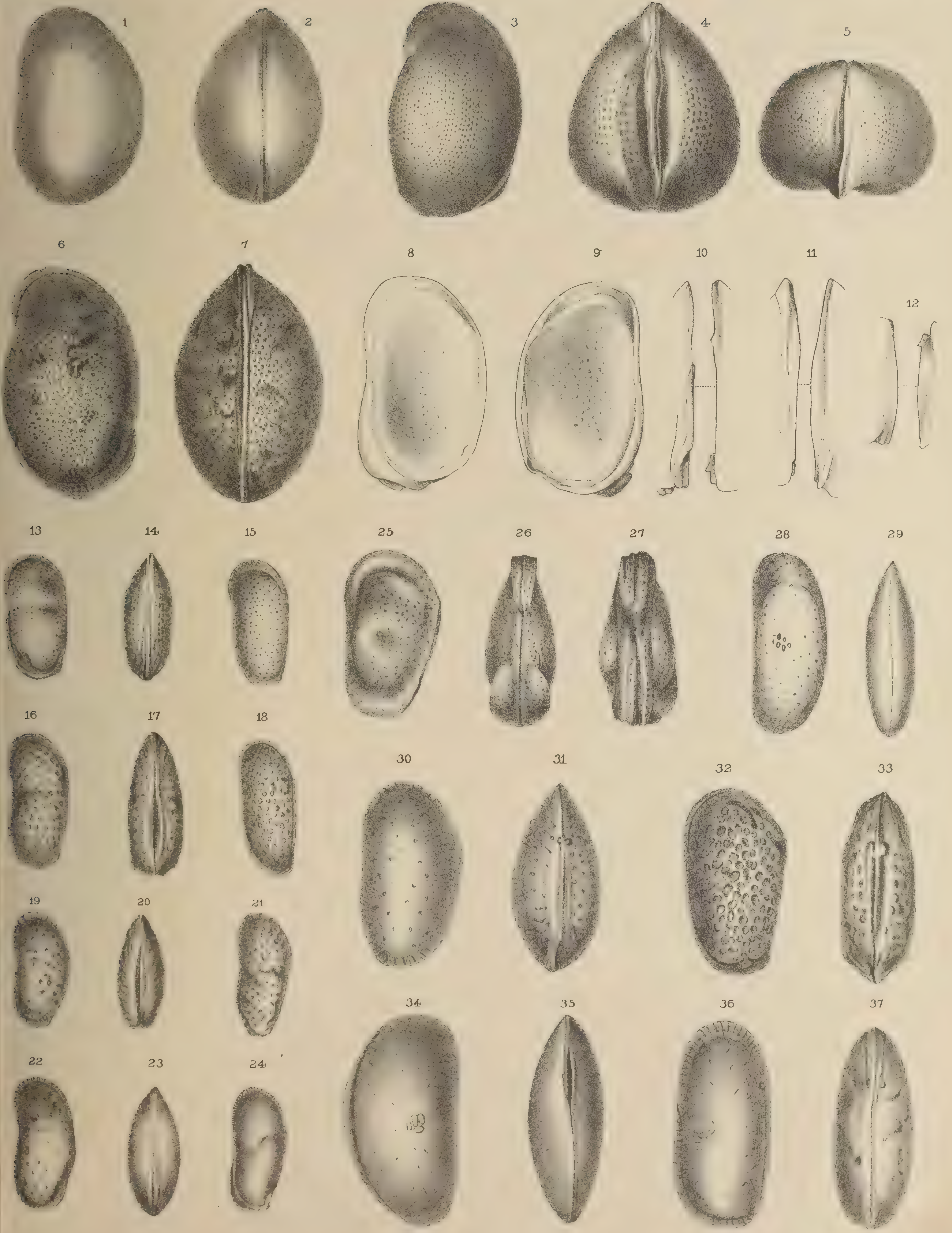
32.	Shell, seen from left side, . . .	× 84
33.	,, ,, above, . . .	,,

Bythocypris bosquetiana.

34.	Shell, seen from right side, . . .	× 50
35.	,, ,, above, . . .	,,

Cythere teres.

36.	Shell, seen from left side, . . .	× 80
37.	,, ,, above, . . .	,,



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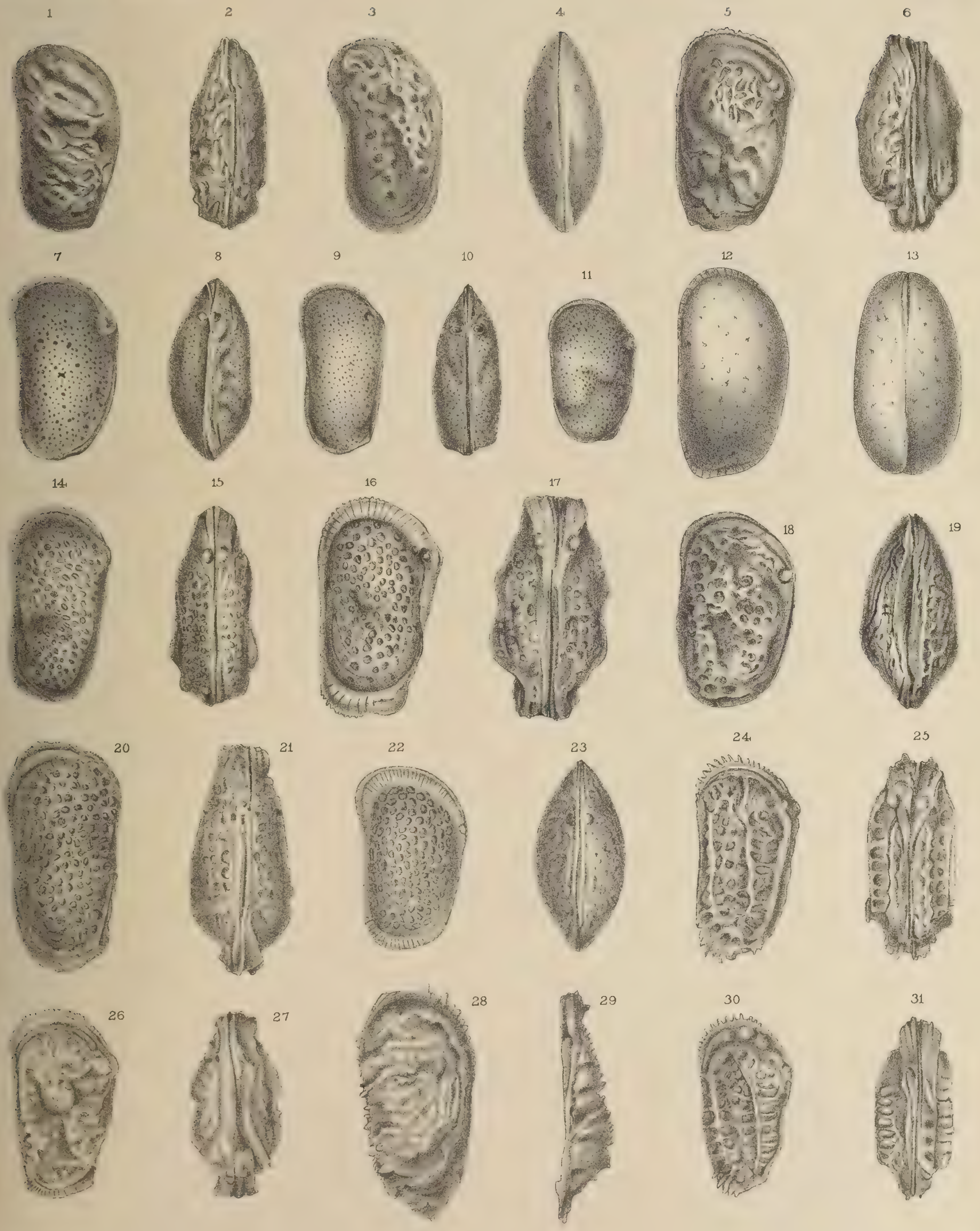
EXPLANATION OF PLATE XV.

PLATE XV.

Figure.		
1.	Cythere crispata, seen from left side, ...	× 80
2.	,, ,, ,, above, ...	,,
3.	,, badia, ,, left side, ...	× 70
4.	,, ,, ,, above, ...	,,
5.	,, crenulata, seen from left side, ...	× 50
6.	,, ,, ,, above, ...	,,
7.	,, pulchella, ,, left side, ...	,,
8.	,, ,, ,, above, ...	,,
9.	,, fuscata, male, seen from left side, ...	,,
10.	,, ,, ,, ,, above, ...	,,
11.	,, ,, female, ,, left side, ...	,,
12.	,, leioderma, ,, left side, ...	× 40
13.	,, ,, ,, above, ...	,,
14.	,, canadensis, ,, left side, ...	× 60
15.	,, ,, ,, above, ...	,,
16.	,, latimarginata, ,, left side, ...	× 50
17.	,, ,, ,, above, ...	,,
18.	,, borealis, female, ,, left side, ...	× 40
19.	,, ,, ,, ,, above, ...	,,
20.	,, lepida, ,, left side, ...	× 50
21.	,, ,, ,, above, ...	,,
22.	,, rubida, ,, left side, ...	× 60
23.	,, ,, ,, above, ...	,,
24.	,, runcinata (female ?) left side, ...	× 40
25.	,, ,, ,, seen from above, ...	,,
26.	,, hoptonensis, seen from left side, ...	× 50
27.	,, ,, ,, above, ...	,,
28.	,, scabrocuneata, right valve, from outside, . . .	× 40
29.	,, ,, ,, ,, above, . . .	,,
30.	,, runcinata (male ?) seen from left side, . . .	,,
31.	,, ,, ,, ,, above, . . .	,,



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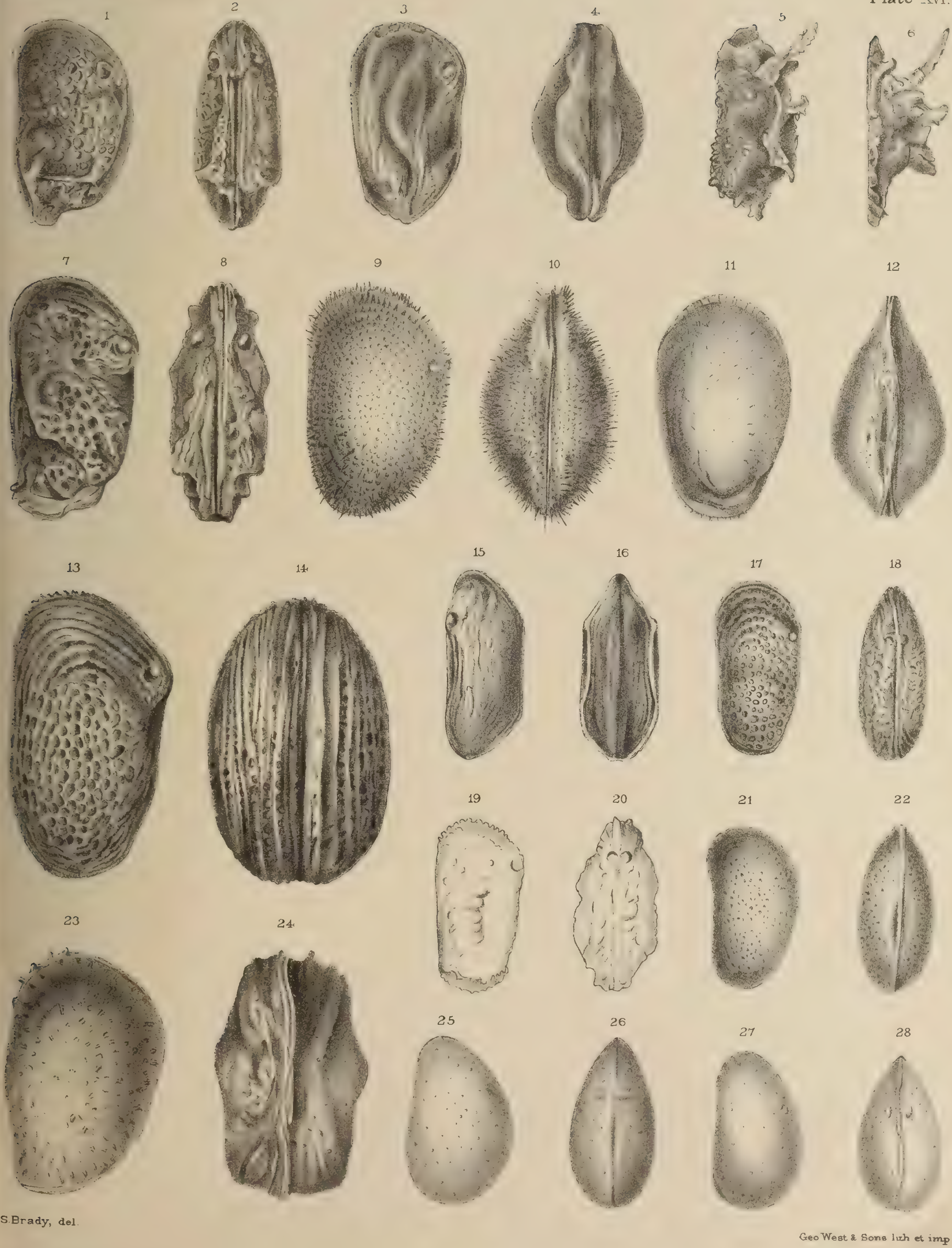
EXPLANATION OF PLATE XVI.

PLATE XVI.

Figure.		
1.	Cythere emarginata, female, seen from left side, . .	× 50
2.	,, ,, ,, ,, above, . .	,,
3.	,, bradii, ,, ,, left side, . .	,,
4.	,, ,, ,, ,, above, . .	,,
5.	,, trispicata, right valve, ,, outside, . .	× 60
6.	,, ,, ,, ,, above, . .	,,
7.	,, costata, female, ,, left side, . .	× 40
8.	,, ,, ,, ,, above, . .	,,
9.	,, echinata, ,, ,, left side, . .	,,
10.	,, ,, ,, ,, above, . .	,,
11.	,, corpulenta, female, seen from left side, . .	× 80
12.	,. ,, ,, ,, above, . . .	,,
13.	,, septentrionalis, from left side, ...	× 40
14.	,, ,, ,, below, ...	,,
15.	,, navicula, from left side, ...	× 84
16.	,, ,, ,, below, ...	,,
17.	,, cribrosa, from left side, ...	× 60
18.	,, ,, ,, above, ...	,,
19.	,, dawsoni, ,, left side, ...	—
20.	,, ,, ,, above, ...	,,
21.	Cytheridea stigmosa, from left side, ...	× 100
22.	,, ,, ,, above, ...	,,
23.	,, fascis, ,, left side, ...	× 60
24.	,, ,, ,, above, ...	,,
25.	Xestoleberis margaritea, from left side, ...	× 50
26.	,, ,, ,, above, ...	,,
27.	,, labiata, ,, left side, ...	,,
28.	,, ,, ,, above, ...	,,



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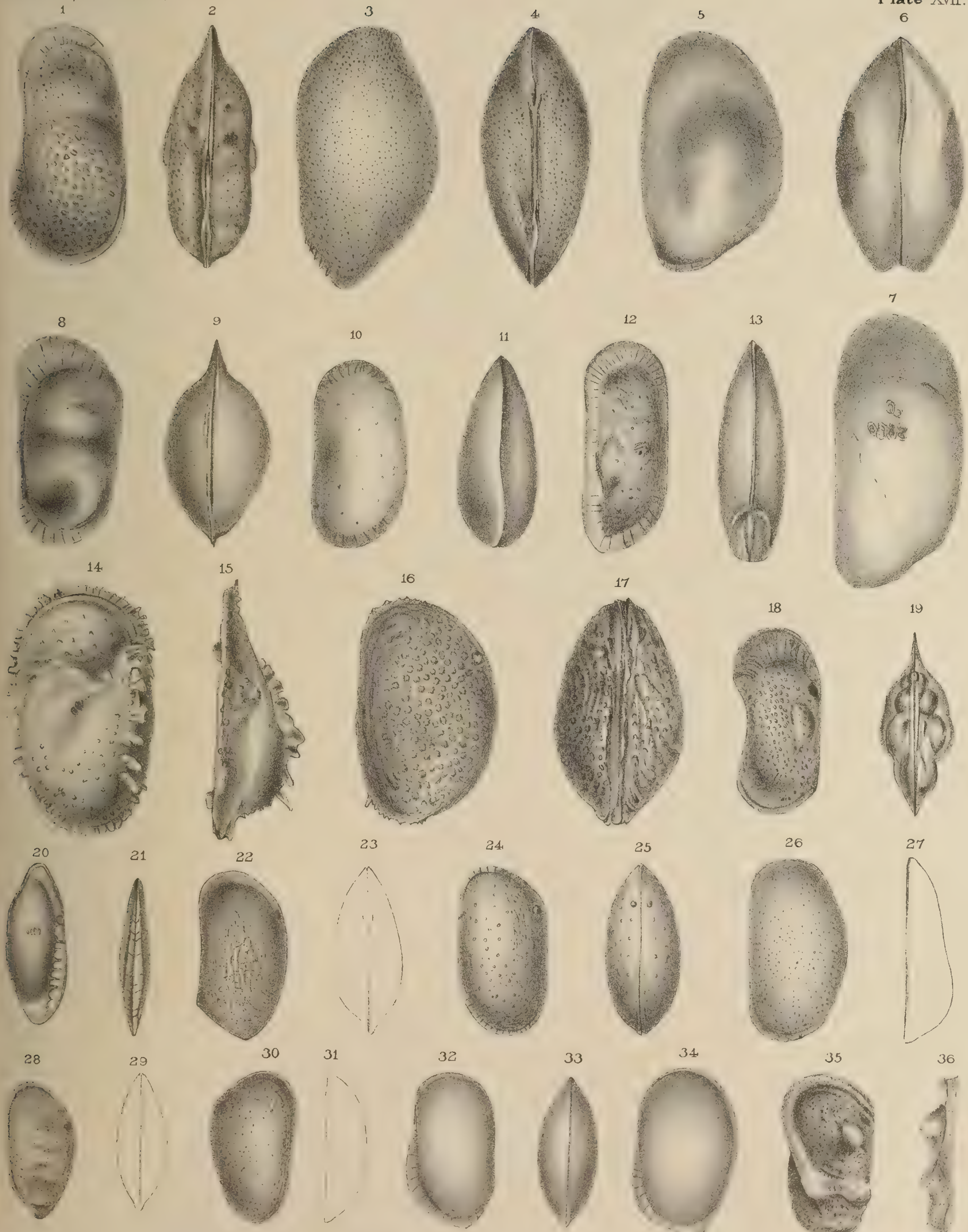
EXPLANATION OF PLATE XVII.

PLATE XVII.

Figure.		
1.	Limnicythere sancti-patricii, male, seen from left side, .	× 60
2.	,, ,, ,, ,, ,, above, .	,,
3.	Bairdia crosskeiana, seen from left side, ...	× 40
4.	,, ,, ,, above, ...	,,
5.	Krithe producta, female, seen from left side, . . .	× 40
6.	,, ,, ,, ,, above, . . .	,,
7.	,, ,, male, ,, left side, . . .	,,
8.	Limnicythere relicta, seen from left side, . . .	× 60
9.	,, ,, ,, above, . . .	,,
10.	Krithe angusta, female, seen from left side, . . .	× 80
11.	,, ,, ,, ,, above, . . .	,,
12.	,, ,, male, ,, left side, . . .	,,
13.	,, ,, ,, ,, above, . . .	,,
14.	Cythere audax, right valve, seen from outside, . . .	× 40
15.	,, ,, ,, ,, above, . . .	,,
16.	,, speyeri, seen from left side, ...	× 50
17.	,, ,, ,, above, ...	,,
18.	Limnicythere inopinata, *var.* compressa, seen from left side,	× 60
19.	,, ,, ,, ,, above, .	,,
20.	Machaerina amygdaloides, seen from right side, . .	× 40
21.	,, ,, ,, below, . . .	,,
22.	Cytherura atra,* seen from left side, ...	—
23.	,, ,, ,, above, ...	—
24.	Loxoconcha pusilla, seen from left side, ...	× 84
25.	,, ,, ,, above, ...	,,
26.	Cytheridea similis, left valve, seen from outside, . .	× 40
27.	,, ,, ,, ,, below, . .	,
28.	Cytherura concentrica (?), young shell, seen from left side,	× 80
29.	,, ,, ,, ,, above, .	,,
30.	Cythere m'chesneyi, right valve, seen from outside, .	× 50
31.	,, ,, ,, ,, above, .	,,
32.	Loxoconcha fragilis, male, seen from left side, . .	× 70
33.	,, ,, ,, ,, above, . . .	,,
34.	,, ,, female, ,, left side, . . .	,,
35.	Cythere cluthæ, left valve, seen from outside, . . .	× 80
36.	,, ,, ,, ,, above, . . .	,,

* The outlines are after G. O. Sars, the sculpture from a fossil specimen.

Plate XVII.



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EXPLANATION OF PLATE XVIII.

PLATE XVIII.

Cytherura simplex.

Figure.		
1.	Shell, seen from left side, ...	× 100
2.	,, ,, above, ...	,,

Cytherura sella.

3.	Shell of male, seen from left side, ...	× 100
4.	,, ,, ,, above, ...	,,
5.	,, female, ,, left side, ...	,,
6.	,, ,, ,, above, ...	,,

Cytherura similis

7.	Shell of female, seen from left side, ...	× 80
8.	,, male, ,, ,, ...	,,
9.	,, ,, ,, above, ...	,,

Cytherura rudis.

10.	Shell of male, seen from left side, ...	× 80
11.	,, ,, ,, above, ...	,,
12.	,, female, ,, left side, ...	,,

Cytherura gibba.

13.	Shell of female, seen from left side, ...	× 80
14.	,, ,, ,, above, ...	,,
15.	,, male, ,, left side, ...	,,
16.	,, ,, ,, above, ...	,,

Cytherura striata.

17.	Shell of female, seen from left side, ...	× 100
18.	,, ,, ,, above, ...	,,

Cytherura affinis.

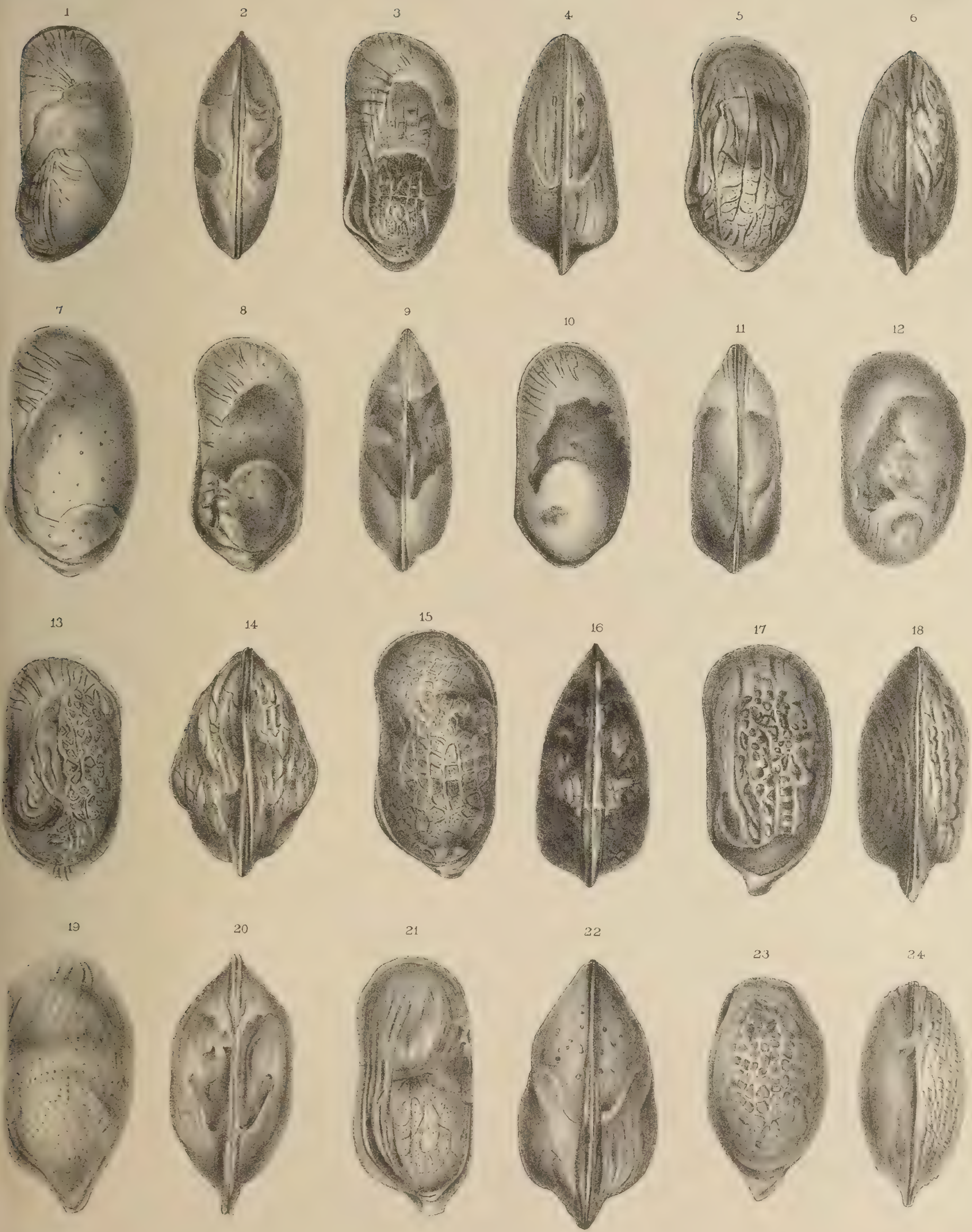
19.	Shell, seen from left side, ...	× 80
20.	,, ,, above, ...	,,

Cytherura cornuta.

21.	Shell of male, seen from left side, ...	× 80
22.	,, ,, ,, above, ...	,,

Cytherura groenlandica.

23.	Shell, seen from left side, ...	—
24.	,, ,, above, ...	—



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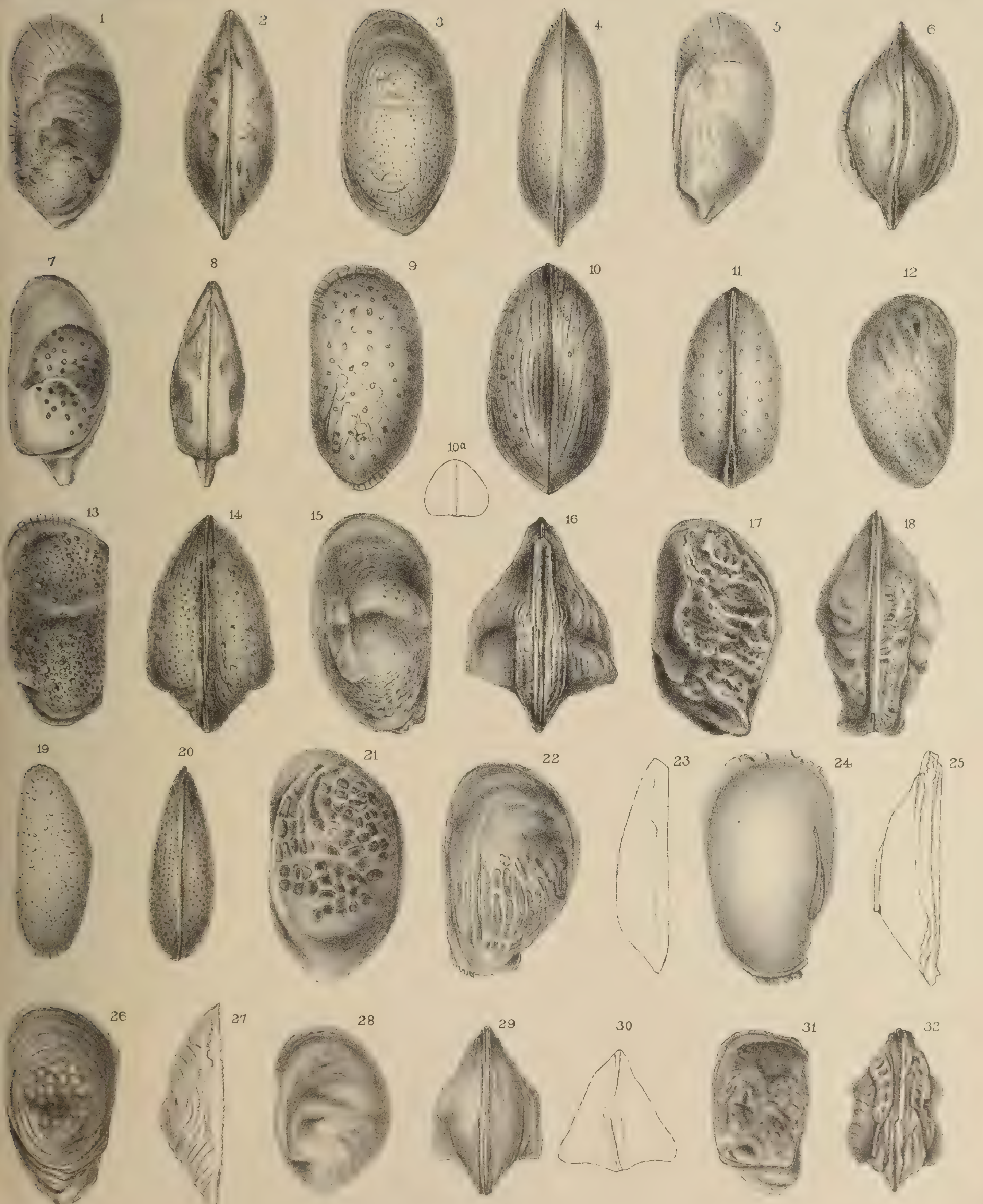
EXPLANATION OF PLATE XIX.

PLATE XIX.

Figure.		
1.	Cytherura nigrescens, female, seen from left side, . .	× 100
2.	,, ,, ,, ,, above, . .	,,
3.	,, concentrica, ,, left side, . .	× 80
4.	,, ,, ,, above, . .	,,
5.	,, producta, ,, left side, . .	,,
6.	,, ,, ,, above, . .	,,
7.	,, angulata, ,, left side, . .	,,
8.	,, ,, ,, above, . .	,,
9.	,, fulva, female, ,, left side, . .	,,
10.	,, ,, ,, ,, above, . .	,,
10*a*.	,, ,, end view, ...	× 40
11.	,, ,, male, seen from above, . . .	× 80
12.	,, undata, ,, right side (junior), .	,,
13.	Bythocythere recta, seen from left side, ...	,,
14.	,, ,, ,, above, ...	,,
15.	,, bicristata, seen from left side, . . .	× 66
16.	,, ,, ,, above, ...	,,
17.	Cytheropteron angulatum, seen from left side, . . .	× 80
18.	,, ,, ,, above, ...	,,
19.	Cytherideis foveolata, ,, left side, . . .	× 50
20.	,, ,, ,, above, ...	,,
21.	Cytherura rudis, *var.*, from left side, . . .	× 80
22.	Cythere sulcifera, left valve, from outside, . . .	× 40
23.	,, ,, ,, ,, above, ...	,,
24.	Bythocythere recurva, right valve, from outside, . .	× 80
25.	,, ,, ,, ,, above, . .	,,
26.	Cytheropteron montrosiense, left valve, from outside, .	× 80
27.	,, ,, ,, ,, above, .	,,
28.	,, arcuatum, seen from left side, ...	,,
29.	,, ,, ,, above, ...	,,
30.	,, ,, ,, behind, ...	,,
31.	Cythere complexa, seen from left side, ...	,,
32.	,, ,, ,, above, ...	,,



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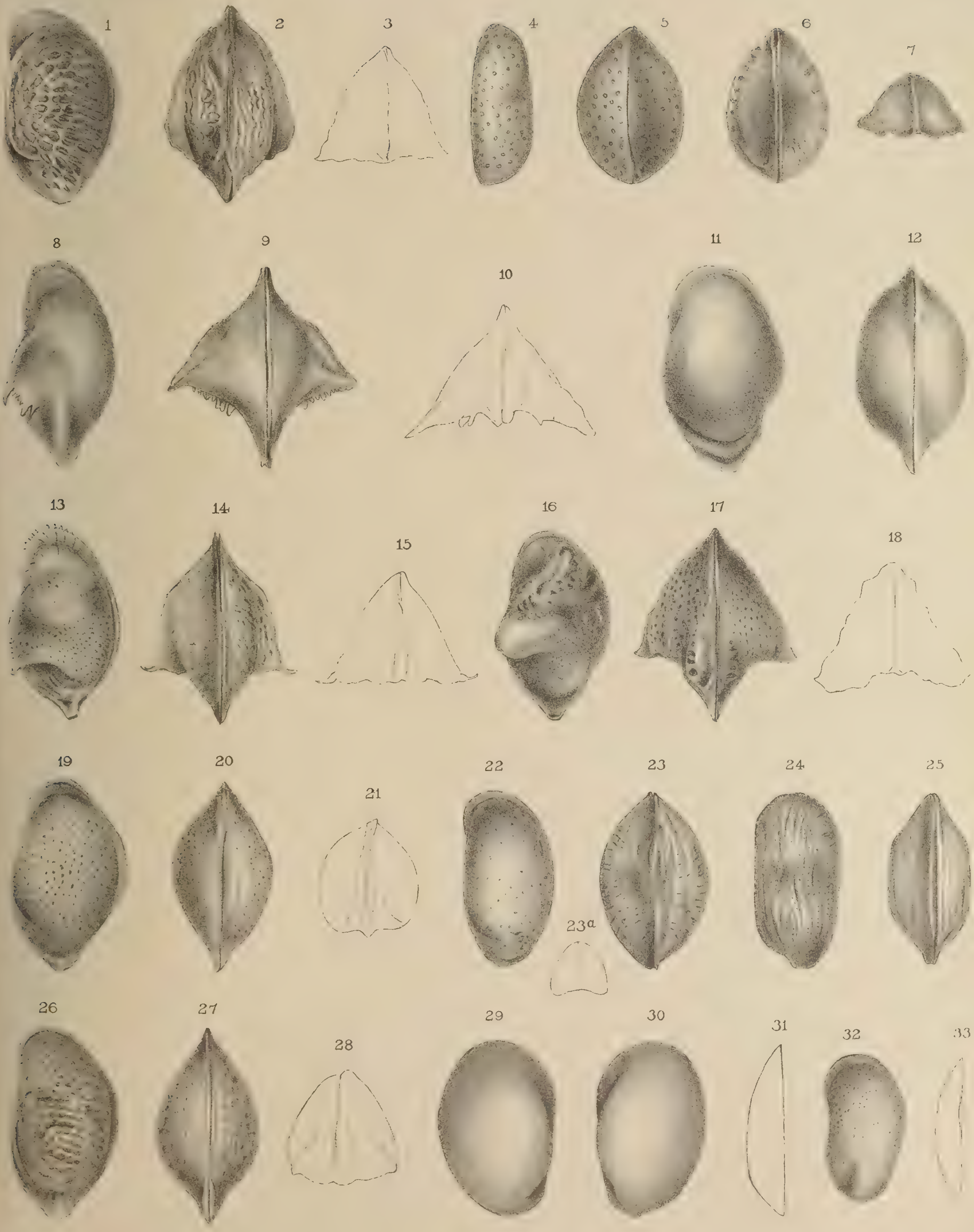
EXPLANATION OF PLATE XX.

PLATE XX.

Figure.		
1.	Cytheropteron pyramidale, male, seen from left side,	× 50
2.	,, ,, ,, ,, above,	,,
3.	,, ,, ,, ,, behind,	,,
4.	,, humile, seen from left side,	× 80
5.	,, ,, ,, above,	,,
6.	,, ,, ,, below,	,,
7.	,, ,, ,, behind,	,,
8.	,, alatum, ,, left side,	× 50
9.	,, ,, ,, above,	,,
10.	,, ,, ,, behind,	,,
11.	Bythocythere dromedaria, seen from left side,	× 50
12.	,, ,, ,, above,	,,
13.	Cytheropteron hamatum, seen from left side,	× 60
14.	,, ,, ,, above,	,,
15.	,, ,, ,, behind,	,,
16.	,, crassipinnatum, seen from left side,	× 80
17.	,, ,, ,, above,	,,
18.	,, ,, ,, behind,	,,
19.	,, inflatum,* ,, left side,	× 50
20.	,, ,, ,, above,	,,
21.	,, ,, ,, behind,	,,
22.	,, depressum, ,, left side,	× 80
23.	,, ,, ,, below,	,,
23*a*.	,, ,, ,, end view,	× 50
24.	Cytherura exserta, seen from left side,	× 100
25.	,, ,, ,, above,	,,
26.	Cytheropteron subcircinatum, seen from left side,	× 80
27.	,, ,, ,, above,	,,
28.	,, ,, ,, behind,	,,
29.	,, læve, right valve from outside,	× 50
30.	,, ,, left ,, ,,	,,
31.	,, ,, ,, ,, from above,	,,
32.	Cythere mamillata, left valve from outside,	× 80
33.	,, ,, ,, from above,	,,

* The figures of this species are drawn from a fossil specimen.



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EXPLANATION OF PLATE XXI.

PLATE XXI.

Figure.	*Cytheropteron testudo*	
1.	Shell, seen from left side, ...	× 80
2.	,, ,, above, ...	,,
	Cytheridea castanea.	
3.	Shell, seen from left side, ...	× 40
4.	,, ,, above, ...	,,
	Paradoxostoma arcuatum.	
5.	Shell, seen from left side, ...	× 80
6.	,, ,, above, ...	,,
	Paradoxostoma hodgii.	
7.	Shell, seen from left side, ...	× 80
8.	,, ,, above, ...	,,
	Paradoxostoma productum.	
9.	Shell, seen from left side, ...	× 80
10.	,, ,, above, ...	,,
	Paradoxostoma flexuosum.	
11.	Shell, seen from left side, ...	× 80
12.	,, ,, above, ...	,,
	Machærina tenuissima.	
13.	Shell, seen from left side, ...	× 40
14.	,, ,, above, ...	,,
	Paradoxostoma hibernicum.	
15.	Shell of female, seen from left side, ...	× 60
16.	,, ,, ,, above, ...	,,
17.	,, male, ,, left side, ...	,,
	Paradoxostoma orchadense.	
18.	Shell, seen from left side, ...	× 80
19.	,, ,, above, ...	,,
	Cytherois fischeri.	
20.	Shell of female, seen from left side, ...	× 80
21.	,, ,, ,, above, ...	,,
22.	,, male, ,, left side, ...	,,
	Krithe reniformis.	
23.	Shell, seen from left side, ...	× 80
24.	,, ,, above, ...	,,
	Paradoxostoma fasciatum.	
25.	Shell, seen from left side, ...	× 50
26.	,, ,, above, ...	,,
	Paradoxostoma vitreum.	
27.	Shell, seen from left side, ...	× 80
28.	,, ,, above, ...	,,
	Paradoxostoma pulchellum.	
29.	Shell, seen from left side, . . . , . .	× 80
30.	,, ,, above, ...	,,

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EXPLANATION OF PLATE XXII.

PLATE XXII.

Ilyocypris gibba (*female*).

Figure.

1. Antenna.
2. Mandible.
3. First maxilla.
4. Second maxilla.
5. Distal half of second foot.

Cytherura gibba.

6. Antennule.
7. Antenna.
8. Mandible.
9. First maxilla.
10. Copulative organs of male.
11. Terminal portion of same more highly magnified.
12. Portion of shell.

Potamocypris fulva.

13. Antennule.
14. Antenna.
15. Mandible.
16. Second foot.
17. Copulative organ of male, with coil of spermatic filaments.

Pontocypris trigonella.

18. Antennule.
19. Antenna.
20. Mandible.
21. Second maxilla of female.
22. Second maxilla of male.
23. Foot of first pair.
24. Foot of second pair.
25. Caudal ramus.


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EXPLANATION OF PLATE XXIII.

PLATE XXIII.

Figure.						
1.	Bythocythere insignis,* shell, seen from right side, .				.	—
2.	,,	,,	,,	,, above,	. .	—
3.	Paradoxostoma rostratum,* shell, seen from right side,				.	—
4.	,,	,,	,,	,, left side,	.	—
5.	Darwinula stevensoni, female, valve removed so as to show animal.					
6.	Pontocypris trigonella, female,	,,	,,			
7.	Loxoconcha impressa, female,	,,	,,			
8.	Cytherura gibba,† male,	,,	,,			
9.	Bythocythere simplex, female,	,,	,,			
10.	Paradoxostoma variabile, male,	,,	,,			

(*a*) antennule.
(*b*) antenna.
(*c*) poison-gland.
(*d*) flagellum.
(*e*) mandible.
(*f*) mandible-palp.
(*g*) labrum.
(*h*) labium.
(*i*) first maxilla.
(*k*) second maxilla.
(*l*) first foot.
(*m*) second foot.
(*n*) third foot.
(*o*) appendages at base of first pair of feet.
(*p*) abdomen.
(*q*) caudal rami.
(*r*) copulative organ of male.
(*s*) convoluted process of same.
(*t*) ova.

* After drawings by Prof. G. O. Sars.

† The mandible in fig. 8 is drawn out of position, and too near the front of the animal.

G. S. Brady, del. et lith.

Geo West & Sons imp.

III.

OBSERVATIONS OF THE PLANET JUPITER, MADE WITH THE REFLECTOR OF THREE FEET APERTURE, AT BIRR CASTLE OBSERVATORY, PARSONSTOWN. By OTTO BOEDDICKER, Ph. D. Plates XXIV. to XXX.

[Communicated by The Earl of Rosse, LL.D., F.R.S., President, November, 1888.]

The Drawings of the Planet Jupiter published herewith were made during the years 1881 to 1886, at Birr Castle Observatory. During this time eighty complete drawings and four sketches of single belts only were made, which are distributed in the following way over the different oppositions:—

1881–1882, twenty-two.
1882–1883, thirty-one.
1883–1884, twenty-one.
1884–1885, eight.
1885–1886, two.

The falling off in numbers during the two last oppositions finds its explanation in the fact, that my time was then thoroughly occupied by a large detailed drawing of the Milky Way, which is now completed, and likely to be ready for publication early next year.

The Jupiter drawings were all made with the reflector of three feet aperture; but as during the period of drawing the speculum had to be repolished repeatedly—once a-year at least—it cannot exactly be said that they were all made under the same instrumental conditions, the speculum being practically a new one after each process of repolishing. The sketches were all executed with pencil and stump, not more than ten minutes being on the average devoted to each of them. They are reproduced by a photo-mechanical process by Wilhelm Hoffmann, Marschallstrasse, Dresden, directly from the originals, in order to avoid the inaccuracies frequently caused by the transferring lithographer. Besides this, the originals have not been touched in any way whatever, as I consider the value of a reproduction like the

present one so much the greater, the more accurately it represents the drawings just as they were obtained at the telescope. This accounts for some obvious errors, *e. g.* the want of parallelism between the belts and the equator (very conspicuous in Nos. 10 and 13). This is owing to an oversight in sketching; belts and equator should, generally speaking, be parallel throughout. As the drawings had to be executed by rather feeble lamplight, they will naturally most nearly represent what was really seen by the observer if looked at in a similar light. This point seems to deserve more attention than it usually receives. Many of the published drawings show detail of a considerable and somewhat unnatural sharpness and boldness, a feature which, to a considerable extent, disappears if those drawings are looked at in the same subdued light in which they had to be done.

In the following I copy from my note-book the remarks made during each observation. All the explanation they require is this, that the Jovian belts are referred to as *a*, *b*, *c*, &c., beginning with the most southern one as *a*. Thus the two most constant and most conspicuous belts occur throughout as *b* and *c*. The intervals between the belts are denoted by the names of these two belts in brackets [*b c*], meaning, for instance, the interval between *b* and *c*. The "red spot" is referred to as *s*.

Without entering into a discussion of the drawings, I may, perhaps, direct attention to the sketches Nos. 48, 49, and 50, which represent the same belt *b* at short intervals of time. I have reproduced them because they illustrate a fact often experienced by me; viz. how what at first is only perceived as unmeaning separate patches seems, in the course of prolonged examination, to combine with fainter surrounding detail into an object of definite character. In our case, the separate dark patches in No. 48, combined with fainter markings, become in Nos. 49 and 50 the shadows of large cumulus-like clouds, lying across the Jovian surface in surprisingly strong relief. How far this process of combination is only subjective it would be difficult to decide: if it is, it shows to how considerable an extent the individuality or a preconceived idea of the observer may unintentionally affect the final appearance of an astronomical drawing. It remains to be added, that the powers used were generally 144 and 216.

Notes to accompany the eighty-four drawings of the Planet Jupiter, as represented in Plates XXIV. to XXX:—

PLATE XXIV., FIGURES 1 to 12.

September, 2, 1881.

1. $13^h\ 12^m$. M. T. Grw. $L = 58^\circ{\cdot}8$. Very clear.

a greyish, southern edge very bright; *b* and *c* reddish yellow, equally dark; *d* fainter, same colour; bright line on *b* and *d*, in traces on *c*; *e* very faint,

hardly perceptible; no distinct clouds between the belts; the "red spot" exceedingly red; its following end seemed sometimes to be darker.

SEPTEMBER 22, 1881.

2. No. 1. $12^h\ 20^m$. $L=157°{\cdot}1$.

a faint, greyish; *b* greyish red; *c* decidedly red; *d* same tint, but brighter; the whole disc pale; limb boiling. Some clearer moments at first, when bright lines were perceptible on *c* and *d*; then *e* was more visible also.

3. No. 2. $13^h\ 27^m$. $L=197°{\cdot}2$. Exceedingly clear.

a faint, greyish, its southern edge very bright; *b* and *c* almost equally dark, hardly any colour perceptible; *d* fainter, bright line on it; *e* very faint. The central cloud in [*b c*] very bright.

OCTOBER 1, 1881.

4. No. 1. $12^h\ 29^m$. $L=77°{\cdot}9$.

a bluish grey, its south edge very bright, in south of it whitish patches; *s* brick red, a very white patch following it; *b* reddish grey, interrupted; *c* brown red, darker than *b*; in [*b c*] cloud-like patches, near the following limb of the disc two very bright ones; *d* reddish grey, as dark as *a*; *e* greyish traces. Enormous quantity of detail.

5. No. 2. $13^h\ 53^m$. $L=128°{\cdot}4$. Definition considerably worse.

Colours not altered, but less distinct; limb sometimes trembling; *d* darker than *a*. Central cloud very bright.

OCTOBER 14, 1881.

6. $12^h\ 17^m$. $L=227°{\cdot}2$. Definition changeable, at times very good. Moonshine.

b c d reddish yellow; *c d* equally dark; *b* darker; *a* very faint, south-edge of *a* rather bright; bright line on *d*. In [*b c*] whitish clouds, not very bright. I thought sometimes I saw bright parallel stripes on the northern hemisphere.

OCTOBER 15, 1881.

7. $12^h\ 53^m$. $L=39°{\cdot}5$. Very clear. Definition excellent. Enormous quantity of detail. Colours very decided.

s bright brick red, blunt-pointed on both ends; *a* bluish grey; *b* same colour, but darker; *c* reddish yellow; *d* same colour, but fainter. Clouds in

[*b c*] in very strong relief. In *a* near *s* white cloudish interruptions (small spots). The faint features towards the poles bluish grey, with very bright lines between.

OCTOBER 30, 1881.

8. No. 1. $9^h\,50^m$. L = 27°·4. Definition and clearness moderate; sky slightly hazy. Moonlight. Markings not very distinct. Sketch not very satisfactory.

s very red; its following end a blunt point; this at the preceding one not so (if at all) conspicuous; *a* greyish; *b c d* reddish grey; *b* darkest; *e* suspected. Hardly any markings in [*b c*]. Satellite shadow very dark.

9. No. 2. $12^h\,48^m$. L = 135°·3. Definition excellent.

a greyish with white patches; *b* reddish grey; the darkest part immediately following the central meridian decidedly blue; *c* and *d* brick red; *c* somewhat darker than *d*; *e* consists of bluish-grey spots. Very white clouds in [*b c*].

NOVEMBER 17, 1881.

10. $13^h\,8^m$. L = 336°·7. Very clear.

a bluish, patchy, one very bright stripe in it; near *s*, especially near its following end, rather dark; *s* exceedingly red, flame-like brick red, slanting towards south at its preceding end, not parallel with *b*; its preceding end a blunt point. In [*a b*] extremely faint bluish traces; *b* bluish grey; *c* and *d* yellowish grey; *c* darker than *d*; on *d* light cloud-like patches; *e* bluish, consisting of two darker stripes (the northern of which repeatedly interrupted) enclosing one very bright one.

NOVEMBER 19, 1881.

11. $10^h\,58^m$. L = 199°·4. Interrupted by clouds; definition, however, pretty good. Not much difference of colour; the belts yellowish grey.

a considerably fainter than the other belts; very bright white patches in it. The northern shadows of the clouds in [*b c*] are bluish, especially that of the cloud nearest to preceding limb. The division between the clouds just following the central meridian very blue, which becomes more conspicuous the more the spot advances on the disc. Very bright lines in *e*. Delicate (greyish) shading on the northern part of the disc.

NOVEMBER 24, 1881.

12. $11^h\ 20^m$. L = 245°·2.

a grey, the dark part just on central meridian bluish; *b c d* yellowish (orange); [*a b*] very bright, the clouds in [*b c*] rather so; the two small round ones nearest to following limb very distinct. I thought I saw white traces in [*c d*] and on *d*. Very bright patches (lines) in *e*. Greyish shading on the northern part of the disc (north of *e*).

PLATE XXV., FIGURES 13 TO 24.

NOVEMBER 25, 1881.

13. $11^h\ 6^m$. L = 27°·9. Striking difference of colours.

a bluish; *b* more grey; *c d* yellowish grey; cloud-shadows in [*b c*] blue; *e* bluish grey Bright lines in south of *a* and in *e*; clouds in [*b c*] bright. Satellite on the disc very bright, at $11^h\ 14^m$ the Satellite just emerging from, and its shadow just entering on, the disc; *s* exceedingly bright brick red, flame-like, with blunt points; these latter, however, not very distinct; *b c d* almost equal in darkness; *a* somewhat fainter.

NOVEMBER 30, 1881.

14. $10^h\ 44^m$. L = 46°·5. Fairly clear. Moonshine.

a bluish, its southern limb very bright; nothing with certainty seen in south of it; *s* very red, bright brick red, blunt points suspected, not very distinct; *b* yellowish grey, cloud-shadows in [*b c*] blue; *c d* more reddish yellow; *c* in north of central cloud darkest; *e* bluish; north of *e* delicate bluish-grey shading. Difference of colour not very decided.

DECEMBER 7, 1881.

15. $9^h\ 2^m$. L = 318°·6. Definition pretty good. Bright moonshine.

Colours not very decided; *s* brick red; *a* (near *s*) and the cloud shadows in [*b c*] bluish; the central clouds [*b c*] very bright; *b c d* yellowish, considerably less distinct near the following limb than near the preceding one; *e* consists of a very bright line with a dark one in south and two bluish patches in north.

December 9, 1881.

16. $10^h\ 26^m$. L = 310°·1. Very clear. Definition very good.

a bluish, its following part darkest; *s* just with difficulty perceptible; *b c d* reddish yellow; *b* darkest; *c* perhaps equally dark. Cloud-divisions in [*b c*] decidedly blue; *e* bluish grey with bright lines. All the markings become sooner indistinct towards the following limb than towards the preceding one.

December 14, 1881.

17. $9^h\ 53^m$. L = 322°·4. Image very steady. Definition very good.

a yellowish, near *s* bluish; *s* brick red, blunt point; *b c d* reddish yellow, cloud-divisions in [*b c*] bluish grey; *e* grey with a very bright line. There is a small white spot in *b* near the central meridian, and a darker one just over the following cloud-division. Traces of white clouds in [*c d*].

December 21, 1881.

18. $8^h\ 34^m$. L = 247°·7. Definition at times very good. Fog. Jupiter pale.

a rather faint, of a yellowish tinge; *b c d* reddish yellow; the cloud-divisions in [*b c*] decidedly blue; *e* grey, as bright as *a*. The central cloud in [*b c*] very bright.

Jupiter was again examined about $11^h\ 30^m$ by Lord Rosse. The red spot looks mottled, at the ends considerably darker, especially at the preceding one. Between the two ends its appearance is streaky, with darker and brighter patches.

December 22, 1881.

19. Time (?) Fog. Definition excellent. Image perfectly steady.

s very brick red, its following end darker; just preceding this end a whitish spot on *s*; the whole of *s* streaky. In the drawing these markings perhaps a little too dark and too distinct. The colours of the belts not very decided; *a* bluish grey; *b c d* yellowish; *e* consists of grey and silvery lines; *d* of a mottled appearance; the divisions in [*b c*] not distinct, but certainly seen as in drawing.

December 27, 1881.

20. No. 1. $8^h\ 0^m$. L = 50°·1. Definition good. Moonshine.

a bluish grey, patchy; *s* brick red, with indistinct dark spots, as in sketch;

b bluish grey, mottled, interrupted by lighter and darker spots. The shade in south of it, beginning just following *s*, decidedly yellowish red; *c* of the same colour; divisions in [*b c*] indistinct, grey; *d* yellowish red, very mottled, with minute brighter and darker spots; *e* consists of bluish grey irregular patches; [*a b*] just following *s*, rather bright.

21. No. 2. 10^h 2^m. L = 123°·7. Definition good, yet the disc trembling at times. Rather pale.

Colours as before, though not so decided; *a* rather complicated, patchy, difficult to draw; *b* grey; *c d* yellowish; the cloud-division in [*b c*] just following central meridian decidedly blue; *e* faint, consists of bluish grey patches and rather bright lines, difficult to draw.

January 17, 1882.

22. 9^h 49^m. L = 33°·4. Clear. Definition pretty good.

s very red (brick red with orange tinge); its following end appeared at times darker (as in sketch); *a* grey, not very distinct; *b* yellowish grey, rather dark; *c d* yellewish red, equally dark; *e* bluish grey, patchy. The cloud-divisions in [*b c*] bluish. South pole reddish; north pole more bluish-grey shading. The markings sooner indistinct towards the following than towards the preceding limb.

December 7, 1882.

23. No. 1. 10^h 50^m. L = 167°·3. All details difficult and rather faint.

b reddish brown, darkest; *c* (consisting of two stripes) much fainter. These two stripes equally dark, or perhaps the northern one a little darker. In [*b c*] white clouds, especially one on the central meridian, and a small round one preceding it. The dark spot underneath the central cloud decidedly blue.

24. No. 2. 12^h 1^m. L = 210°·1. Definition better than before.

b reddish brown, equally shaded all over; all other spots yellowish, except the belt north of the equator, which is bluish, as also the central dark spot in *c*. This spot slightly darker than the rest of *c*. Southern markings very indistinct.

PLATE XXVI., FIGURES 25 TO 36.

DECEMBER 8, 1882.

25. $11^h\ 29^m$. $L = 341°\cdot4$. Definition rather good.

a and *d* bluish grey; *b* reddish brown, interrupted as in sketch; *c* pale yellowish. In [*b c*] white clouds with bluish intervals, espceially the two dark spots in the following half quite blue. Detail between *b* and *c*, especially the northern spots, not easy. Between the dark northern belts *e* very bright intervals. The belts should be parallel to the equator.

DECEMBER 22, 1882.

26. No. 1. $10^h\ 44^m$. $L = 262°\cdot2$. Clear. Squally. Tube trembling. Disc pale.

b reddish yellow, its following part darkest; interrupted by two small white spots. The equatorial spots (in *c*) pale bluish grey.

27. No. 2. $11^h\ 54^m$ (?). $L = 304°\cdot3$ (?). Not quite so clear as before. Very bright moonshine. Strong gusts; telescope continually trembling, drawing, therefore, very difficult. Sketch not equally reliable in all parts. Northern spots uncertain, also the preceding ones in [*b c*] immediately near the preceding limb. Disc very pale.

b reddish brown; spots north of it (in *c*) bluish.

JANUARY 15, 1883.

28. No. 1. $10^h\ 57^m$. $L = 282°\cdot0$. Very clear and distinct. Moonshine. Disc rather pale.

a and *e* very faint; *b* reddish grey; *c* consists of grey spots, with one very conspicuous white one; *d* yellowish grey.

29. No. 2. $12^h\ 9^m$. $L = 325°\cdot8$. Very clear. Interrupted by passing cirri.

a and *e* faint; *e* consists of different stripes. The dark parts in *b* reddish brown, in *c* decidedly bluish grey, and darker than *d*.

JANUARY 18, 1883.

30. No. 1. $9^h\ 53^m$. $L = 334°\cdot6$. Exceedingly clear; very difficult.

a c d e f pale yellowish; *b* reddish brown.

31. No. 2. $10^h\ 25^m$. L = 354°·0. Hazy, but definition *very* good. Air very steady.

s very pale pink, at first not recognized at all. Other colours as before. In [*c d*] faint patches, hardly to be made out.

32. No. 3. $11^h\ 26^m$. L = 31°·4. Definition worse, yet air steady. Rather thick haze.

s pink, very faint; *b* reddish brown. All the other spots indistinct and difficult; no special colour in them perceptible.

JANUARY 19, 1883.

33. No. 1. $9^h\ 58^m$. L = 128°·1. Very steady and well defined. Frequently interrupted by clouds.

b reddish brown, ends abruptly at the preceding limb; *c* consists of very blue streaks. In [*b c*], just following the satellite-shadow, a rather white spot; [*c d*] mottled; *e* and *f* not with certainty seen divided; in its following half a bluish patch. Both poles shaded; the northern one more so than the southern one.

34. No. 2. $10^h\ 35^m$. L = 150°·5. Very clear. Interrupted by clouds. Clock ran down. Satellite and its shadow visible. Colours as before.

35. No. 3. $11^h\ 18^m$. L = 176°·6. Very clear and well defined. Interrupted by clouds.

b reddish brown; cloud in [*b c*], just following central meridian, brightest. The dark spot in the following half of *c* very blue; [*c d*] has a mottled cloud-like appearance.

36. No. 4. $11^h\ 59^m$. L = 201°·4. Very clear. Colours as before.

a consists of two belts with a rather bright line between them.

PLATE XXVII., FIGURES 37 TO 48.

JANUARY 27, 1883.

37. $11^h\ 22^m$. L = 302°·7. Moderately clear. Squally; very cold.

a very faint; *b* dark brownish red, in it two white spots, one of them immediately at the preceding limb. The dark spot just following the other

white one, and just preceding the central meridian, decidedly and very strikingly blue; *c d* grey; in [*c d*] traces of white patches; *e* more suspected than seen.

JANUARY 30, 1883.

38. No. 1. $8^h\ 44^m$. L = 298°·2. Excellent.

a pale grey; *b* reddish brown; [*b c*] strikingly like white clouds on a darker ground; the dark spot in [*b c*] preceding the central meridian (not on the meridian) decidedly blue; in the following half of [*c d*] a small reddish spot; *e* consists of one or more streaks.

39. No. 2. $9^h\ 20^m$. L = 319°·8. Excellent.

The dark spot near the preceding limb in *b*, blue; the long one in the following half of *b*, reddish brown; the preceding edge of this latter spot very white; immediately under its preceding end (in contact with it) a small blue spot. The darkest patch in the following half of *c* is blue. The markings look most strikingly like clouds lying before each other.

40. No. 3. $10^h\ 17^m$. L = 354°·3. Very good, but difficult.

s exceedingly faint, pink; *a* very faint. The three small spots in *c* (one in preceding and two in following half) blue.

41. No. 4. $10^h\ 55^m$. L = 17°·6.

s very faint, pink; it looks, perhaps, like a cloud with a white edge lying before the other spots. In [*b c*], just underneath *s*, a very bright, small, round spot (Denning's white spot); *a* more distinct than before, its southern edge rather bright.

FEBRUARY 2, 1883.

42. No. 1. $8^h\ 55^m$. L = 38°·2. Very clear. Much detail.

In the following half of a_1 two faint bluish patches; [a_1 *a*] very bright; *a* bluish; *s* pink, faint; *b* brown red; in [*b c*], lying on *b*, two very bright clouds, especially the preceding one, is very white (Denning's white spot); the dark spot in [*b c*] immediately under the following "shoulder" in *b*, and separated from it by a white line, is blue; *c* consists of separate patches; in it, near the following limb, a round white spot; [*c d*] wider near the preceding than near the following limb. In [*e f*], just following central meridian, a very bright spot. In *f* two faint, darker (bluish) patches.

43. No. 2. $9^h\ 56^m$. $L=73°\cdot1$. Very clear. Much detail. Not quite so steady as before.

a_1 very faint; [a] very white; a bluish, with pretty sharp outlines; s pink, indistinct, in drawing rather too near the preceding limb; b reddish brown; the two dark spots in it, as also the one in following half of c, decidedly blue; look strikingly like white-bordered clouds with blue shadows, lying before each other. These spots are surprisingly distinct; d reddish; $e\ f$ bluish grey, faint and difficult.

February 3, 1883.

44. $8^h\ 16^m$. $L=162°\cdot7$. Pretty clear; at times rather unsteady.

a indistinct at times, with very bright horizontal lines; interrupted in its following half; c very decidedly reddish brown. Is the dark hook in [$b\ c$], just following central meridian, of a bluish tinge? The central one and the following one of the three dark patches in c are bluish grey; d brownish; d and e rather bright; e consists of indistinct darker and brighter patches.

February 13, 1883.

45. $8^h\ 32^m$. $L=286°\cdot9$. Misty, and much wind. Tube continually trembling, so that the planet could only be seen in short glimpses. Belt a was sketched.

a considerably changed, decidedly broken up; two bluish-grey patches in it on the middle of the disc, with very bright edges; c not broken up, but a continuous belt, much darker than d. The last belt, e, considerably darker than last time.

March 3, 1883.

46. $7^h\ 54^m$. $L=39°\cdot3$. Clear.

a bluish; s pink; b brownish red, rather dark; c consists of two bluish patches with white ones preceding. These spots look like white clouds with bluish shadows lying on the planet; d brownish grey.

March 4, 1883.

47. $8^h\ 54^m$. $L=225°\cdot7$. Pretty clear; difficult, but sketch correct. Whole disc rather pale.

a consists of very faint grey patches with bright intervals; b reddish yellow.

In [*b c*], near the preceding limb, a very bright round spot, and in its following half a very dark one; *c* grey, partly double, interrupted by a white spot in its following half, which, however, is not so bright as the bright spot in [*b c*]; *d* and *e* grey, indistinct; the central part of *e* somewhat darker.

MARCH 16, 1883.

48. No. 1. $9^h\ 37^m$. $L = 254°{\cdot}6$. Image pretty steady, but not quite clear. Interrupted by clouds.

Jupiter's appearance was very remarkable, especially belt *b*, which was interrupted as in sketch. I was not quite certain whether the preceding interruption went right through, nor whether they are both white. I think there is very light-brown shading in them. Following part of *b* not quite certain.

PLATE XXVIII., FIGURES 49 TO 60.

MARCH 16, 1883.

49. No. 2. $9^h\ 58^m$. $L = 267°{\cdot}2$. Sketch in some respect more correct.

The first interruption does not go quite through. There is a third interruption in *b*, the nature of which was not quite made out.

50. No. 3. $10^h\ 21^m$. $L = 281°{\cdot}1$. Appearance strikingly as in sketch.

MARCH 18, 1883.

51. $9^h\ 24^m$. $L = 187°{\cdot}3$. Pretty clear. Improving during sketching.

a Hardly perceptible, a white spot in its following half; *b* very brown; in [*b c*] white and dark spots; a small, round, very white cloud immediately preceding the central meridian. The dark spots in *c* perhaps slightly bluish. Northern spots very faint; their appearance as in sketch. Configuration of [*b c*] quite correct.

MARCH 27, 1883.

52. $9^h\ 22^m$. $L = 98°{\cdot}6$. Clear. Very difficult.

a Very faint, apparently a division in its preceding half. Near the red spot it is very difficult, and, perhaps, somewhat doubtful. Is there a southern continuation of *b*, so that *b* looks like a fork enclosing *s*? *s* only perceptible as a pink shade without distinct outline. The dark spot in [*b c*], on the central meridian, bluish. In the preceding half of [*b c*] one very white round

spot, surrounded by blue shading. The small dark spot north of this white spot is the darkest spot in *c*, very blue. The spots in *c* sometimes like clouds lying before each other; this, however, not very distinct; *d* one darkish belt; its preceding half darkest. Nothing to be made out in *e* but general shading; there are, perhaps, some darker spots in it.

APRIL 13, 1883.

53. $9^h\ 37^m$. $L = 141°{\cdot}0$. Unsteady; not much detail. .Strong moonshine.

One small whitish cloud in [*b c*] on central meridian; another in the preceding half of *c*. Of *a* nothing, of *d* only general shading seen.

NOVEMBER 13, 1883.

54. $14^h\ 26^m$. $L = 70°{\cdot}5$. Very difficult. Not very clear.

a grey, its northern edge very bright; *b* reddish brown. Sometimes I perceived something pink over the central hole, perhaps a trace of *s*; *c* greyish; *d* consists of ill-defined dark spots. The whole north pole very much shaded. The phase seems to be very perceptible. The dark spot in [*b c*], just on central meridian, decidedly of a bluish tinge. At times there appeared white lines on *b*, but they could not be made out properly. The shading across the hollow in *b* correct; at times rather distinct.

FEBRUARY 24, 1884.

55. No. 1. $11^h\ 13^m$. $L = 338°{\cdot}4$. Middling.

a faint; *b* brownish, division in it difficult; *c* yellowish grey; *d* bluish; *e* (the whole northern half) strongly shaded, bluish grey. In the preceding half of [*b c*] a round white cloud.

56. No. 2. $12^h\ 30^m$. $L = 24°{\cdot}8$. Clear and steady.

a Very faint; *b* difficult, very much as in sketch; *e* separately visible; colours as before. In [*b c*] three whitish patches; in the following half of [*d e*] a white cloud.

57. No. 3. $13^h\ 26^m$. $L = 58°{\cdot}6$. Clear and steady.

a difficult, correct in general appearance, but uncertain in detail; *s* very faint, but unmistakable; *a* and *s* perhaps too dark in drawing. Cloud in [*b c*], just preceding central meridian, rather white.

MARCH 4, 1884.

58. No. 1. $8^h\ 25^m$. L = 150°·5. Very clear.

There is a horizontal division in *a*; *b* reddish. The dark spot in the following half of *c* decidedly blue. The division in *d* more suspected than seen.

59. No. 2. $11^h\ 29^m$. L = 261°·6. Clear, especially towards end of sketching.

a correct, perhaps too dark, the white intervals in it very bright; *b* reddish, difficult. The cloud in the preceding half of [*b c*] very bright and surprisingly rounded. Hardly any, or no detail in the following half of [*b c*]. *d* exceedingly distinct, very blue; *e* separately visible.

MARCH 10, 1884.

60 No. 1. $9^h\ 21^m$. L = 6°·9. Very clear.

a very faint and indistinct, its southern edge very white; whitish patches in *a* and [*a b*]; *b* dark-brown red, with traces of a horizontal division; such traces (but more distinct) also on *c* and *d*; *c* bluish, very sharply defined; very white patches in [*c d*]; *e* bluish grey, patchy; white spots in [*d e*]. North pole slightly shaded.

PLATE XXIX., FIGURES 61 TO 72.

MARCH 10, 1884.

61. No. 2. $11^h\ 1^m$. L = 67°·0. Very clear and steady.

a bluish, its southern edge very bright, slanting; *s* faint. Is its southern limb sharper than its northern one? The region preceding and south preceding *s* very bright. *b* very distinct, brownish-red. Clouds in [*b c*] very distinct, especially the central one. Bright patches in [*c d*] and [*d e*]. *e* seen well separated.

62. No. 3. $12^h\ 5^m$. L = 106°·1. Clear, unequal.

a too dark in sketch, its shape not quite certain either, but certainly seen separated from *s*; the white spot immediately near the following end of *s* very bright; *b* very striking; the horizontal divisions on it very difficult; clouds in [*b c*] very distinct; *d* and *e* seen separated.

MARCH 13, 1884.

63. No. 1. 9^h 42^m. L = 110°·4. Clear, but very unsteady. High wind.

a bluish, with a bright southern limb; in *a*, just following *s*, a very bright spot; *s* pink, its south limb sharper than its northern one; *s* decidedly separated from *a*; *s* lies nearer to the following shoulder of the hollow in *b*; *b* dark-reddish brown, the part just on the central meridian darkest. The white spots in [*b c*] rather cloud-like. Is *c* divided lengthways? *d* consists of rather dark spots; [*c d*] and *d* look very much like a row of white clouds, with dark northern shadows.

64. No. 2. 11^h 17^m. L = 168°·1. Misty, but steady. Constantly interrupted by clouds.

a indistinct and uncertain; *b* remarkably interrupted by bright lines, as in sketch; white spots in [*b c*] rather bright; *c* not so reliable as *b*; *d* very indistinct, more a general shading off.

MARCH 17, 1884.

65. No. 1. 9^h 48^m. L = 355°·5. Clear and steady. Improving.

a indistinct, patchy; *b* correct, very dark, reddish brown; *c* and *d* of an undecided colour. North limb of *c* curved and irregular, as in sketch; *d* broad; spots in [*c d*] like clouds; *e* indistinct, but correct (two darkish spots). Northern half of disc much shaded.

66. No. 2. 12^h 18^m. L = 86°·5.

a indistinct, bluish, one dark spot in it following *s*; *s* separated from *a*. This difficult to see. A white spot follows *s*. The preceding end of *s* is darker than the whole. *b* is interrupted north of *s*, as in sketch. The preceding shoulder of the hollow in *b* is darkest; the following one is not very sharp. The hollow looks somewhat flat; is filled up with light shading. *c* darker than *d*.

MARCH 23, 1884.

67. No. 1. 9^h 43^m. L = 174°·6. Clear, but very difficult.

a exceedingly faint; *b* and *c* on the whole correct; *d* faint; *e* a general shading. The division in *d* correct; at times very conspicuous. *b* is reddish brown. The other markings are more greyish.

68. No. 2. $11^h\ 44^m$. $L = 247°\cdot9$. Clear. Improving.

b reddish brown; a very bright cloud is on the central meridian; *c* is broken up, as in sketch; *d* is very faint.

APRIL 1, 1884.

69. $8^h\ 52^m$. $L = 56°\cdot8$. Clear, but difficult. Little detail.

a faint, with a white spot preceding *s*; *b* dark red-brown, interrupted north of *s*; *b* divided lengthways; *c* yellowish; *d* bluish grey; darkish spots in *e*.

Jupiter was again carefully examined after $10^h\ 20^m$, and *s* was decidedly seen *well separated* from *a*. *s* was followed by a brightish patch, as on former occasions. Belt *b* was interrupted north of *s*, similarly as before. The above seen by Lord Rosse and myself.

APRIL 6, 1884.

70. $9^h\ 54^m$. $L = 125°\cdot8$. At times exceedingly clear. Enormous amount of detail.

s and *a* separated; *a* more distinct than usual; no spots on *s*; *b* very complicated; an interruption in the preceding shoulder of the hollow; *c* yellowish, complicated; central spot in it decidedly blue; *d* and *e* unfinished. *b* is, perhaps, too broad, and not quite dark enough in comparison to *c*.

APRIL 7, 1884.

71. No. 1. $8^h\ 50^m$. $L = 237°\cdot1$. Very clear. Definition very good. Enormous amount of detail. Sketch good.

a exceedingly faint; *b* yellowish; *c* bluish; northern edge of *c* very bright; *d* and *e* as in sketch. In [*b c*] three small clouds, the preceding one of which very bright.

72. No. 2. $9^h\ 56^m$. $L = 277°\cdot4$. Very clear and steady.

a, as in sketch, faint; *b* yellowish; *c* grey; *d* bluish. The cloud in [*b c*] just following central meridian very bright and well defined.

PLATE XXX., FIGURES 73 to 84.

April 8, 1884.

73. No. 1. $9^h\ 14^m$. L = 42°·0. Exceedingly clear and steady.

South edge of *a* rather bright. Are there white spots in *a*? *b* brownish yellow; *c* bluish yellow; *d* bluish. In [*a b*] white clouds. *c* slightly too dark, compared with *b*.

74. No. 2. $10^h\ 9^m$. L = 75°·2. Very clear indeed.

s very faint, the dark spot immediately preceding it bluish. *s* was seen decidedly separated, though this separation, especially from the following streak, very difficult.

February 17, 1885.

75. No. 1. $12^h\ 25^m$. L = 114°·5* Clear, yet Jupiter trembling, and exceedingly difficult. Sketch not very satisfactory. Colours very pale. The dark patch on the southern half of the disc seems to be cut up by bright lines. The belts should be parallel to the equator, and exactly on the middle of the disc.

76. No. 2. $13^h\ 42^m$. L = 161°·3. Clear, but interrupted by clouds. Sketch better, but not quite satisfactory. Jupiter trembling at times. Drawing very difficult.

Colours very pale, hardly perceptible; *d* bluish; [*c d*] very bright.

February 18, 1885.

77. No. 1. $11^h\ 46^m$. L = 249°·1. Fairly clear.

78. No. 2. $12^h\ 51^m$. L = 288°·7. Very clear. Drawing very difficult.

a bluish, patchy, very faint; *b* reddish brown; *d* bluish; north edge of *c* sharp and distinct; *s* decidedly separated from surrounding patches; also of a different colour; *s* reddish, or pink; very faint. In sketch No. 1 *s* is rather too dark.

* *Monthly Notices of the R. A. S.*, vol. xliv., No. 9 (Sup.), 1884.

MARCH 9, 1885.

79. 12^h 39^m. L = 52°·0. Drawing indifferent and incomplete. Everything only caught in short and uncertain glimpses. Definition bad, though sky very clear.

I thought I saw *s* separated from *a*; *s* pink; *a* blue.

MARCH 16, 1885.

80. 10^h 20^m. L = 356°·3. Clear, with interruptions. Drawing not very satisfactory; too much time had to be spent on it.

MARCH 24, 1885.

81. No. 1. 12^h 9^m. L = 249°·9. Jupiter very poor and difficult. Drawing indifferent and poor.

The central darkish connection between *b* and *c* of a slightly bluish shade.

82. No. 2. 13^h 27^m. L. = 297°·2. Better than No. 1. Very steady, but no more to be made out.

b and *c* reddish.

MARCH 6, 1886.

83. 13^h 48^m. L_1 = 44°·1; L_2 = 54°·6.* Very clear and steady. Aperture reduced to 27 inches.

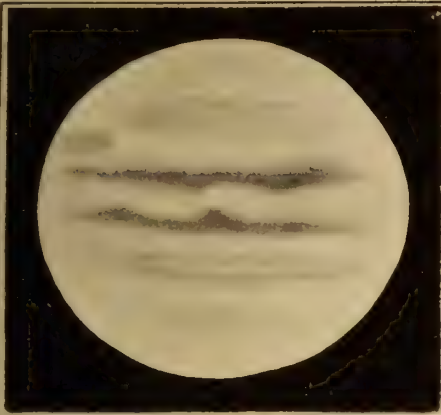
a very faint, its southern edge very bright; *d* comes first in distinctness and darkness (should be darker in sketch); *b* next, its south edge very bright; *c* darker than *b*, its north edge very bright. The colour of *b* and *c* is brownish yellow, but not very conspicuous.

MARCH 13, 1886.

84. 12^h 27^m. L_1 = 24°·9; L_2 = 348°·3. Clear in glimpses. Sketch not very satisfactory; too much time had to be spent on it.

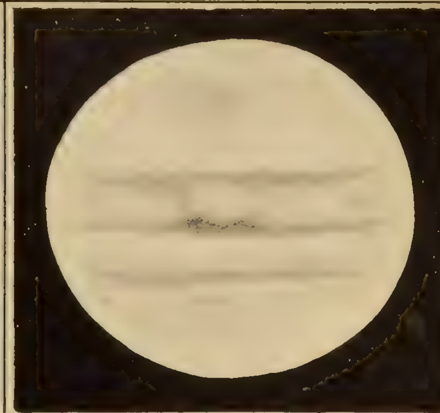
a faint, perhaps bluish; *s* exceedingly faint, pink-red; *a* and *s* separated; *b* and *c* reddish yellow, especially *c*, which is darkest. Two very bright and thick clouds in [*b c*]; *d* very faint indeed, perhaps too dark in sketch. North pole much shaded, bluish grey.

* *Monthly Notices of the R. A. S.*, vol. xlv., No. 9 (Sup.), 1885

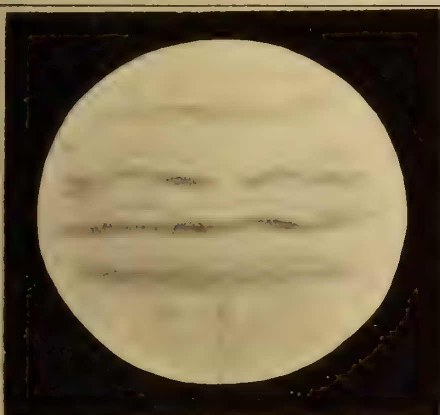


1. 1881 Sept. 2 $13^h 12^m$.

2. 1881 Sept 22. $12^h 20^m$.

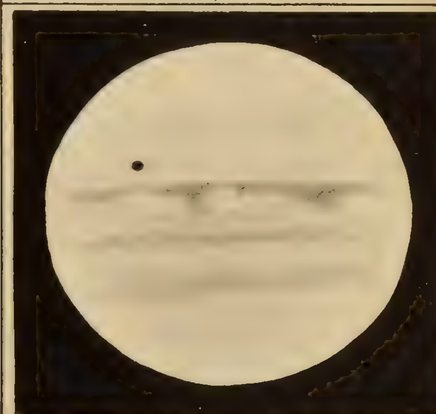


3. 1881 Sept. 22. $13^h 27^m$.

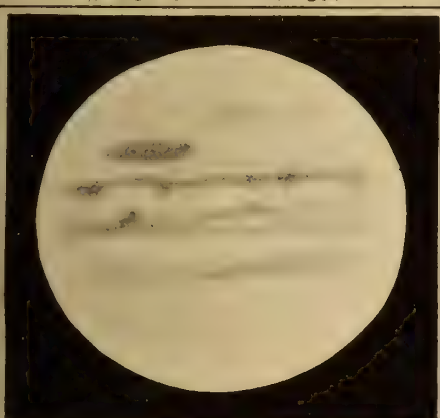


4. 1881 Oct. 1. $12^h 29^m$.

5. 1881 Oct. 1. $13^h 53^m$.

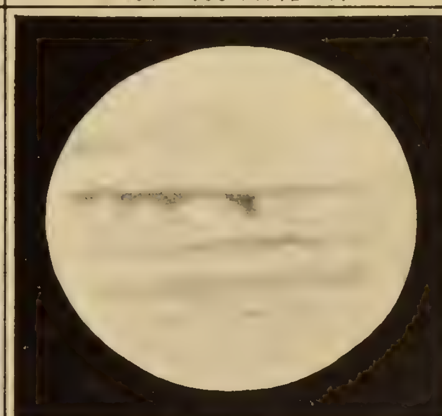


6. 1881 Oct. 14. $12^h 17^m$.

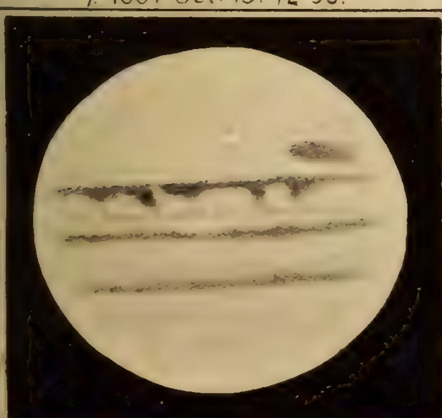


7. 1881 Oct. 15. $12^h 53^m$.

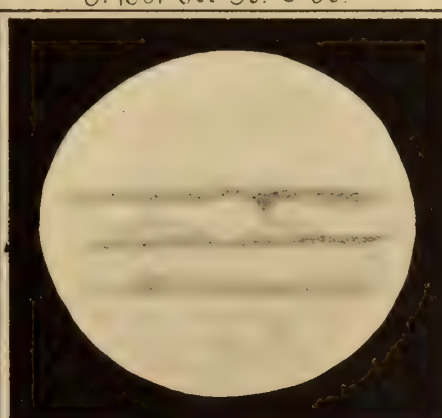
8. 1881 Oct 30. $9^h 50^m$.



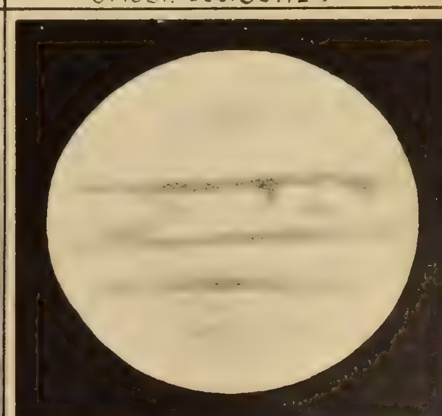
9. 1881. Oct. 30. $12^h 48^m$.



10. 1881 Nov. 17. $13^h 8^m$.



11. 1881 Nov. 19. $10^h 58^m$.



12. 1881 Nov. 24. $11^h 20$.

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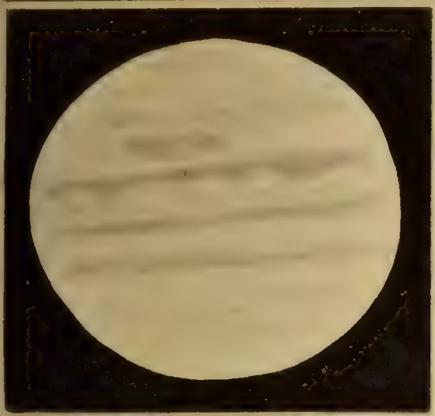
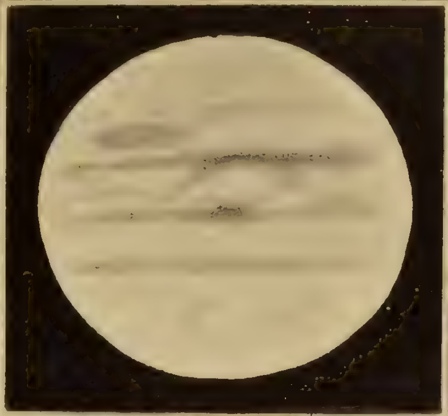
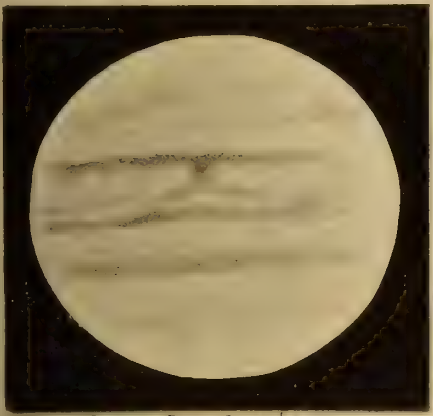


13. 1881 Nov. 25 $11^h 6^m$

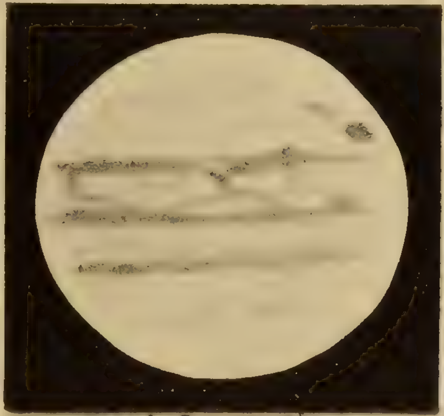


14. 1881 Nov. 30 $10^h 44^m$

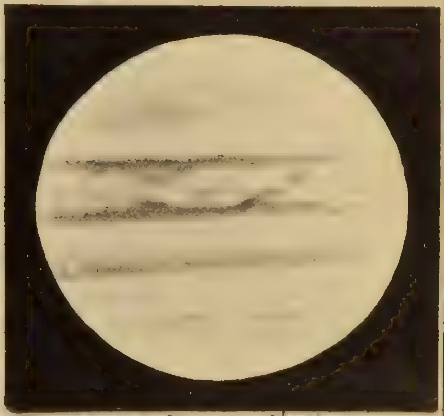
15. 1881 Dec. 7 $9^h 2^m$



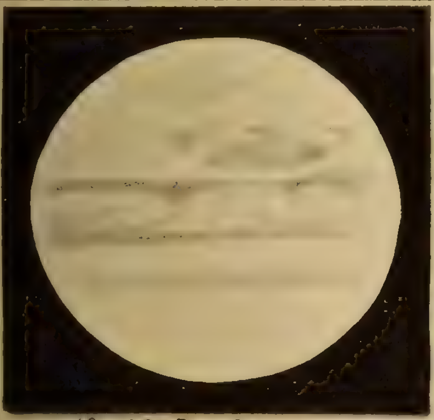
16. 1881 Dec. 9 $10^h 26^m$



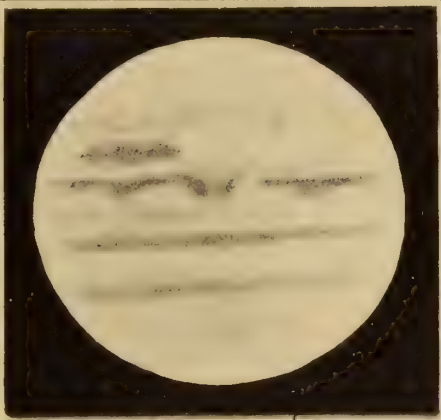
17. 1881 Dec. 14 $9^h 53^m$



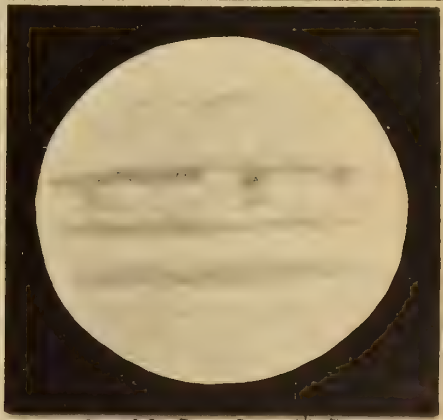
18. 1881 Dec. 21. $8^h 34^m$.



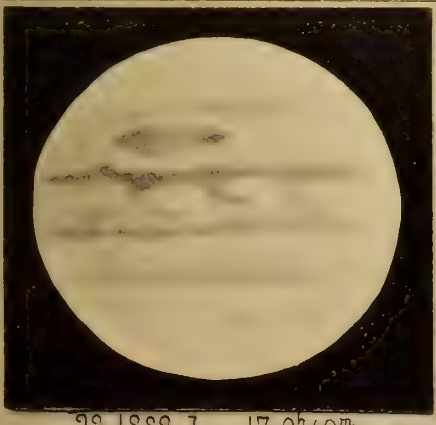
19. 1881 Dec. 22



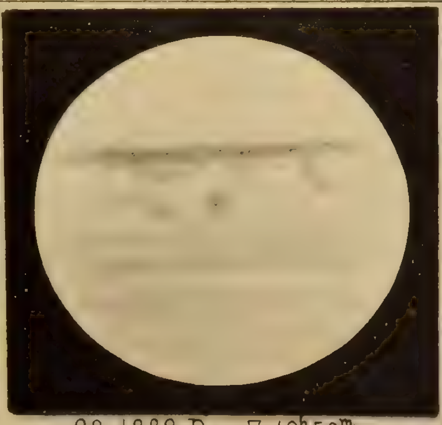
20. 1881 Dec. 27. $8^h 0^m$



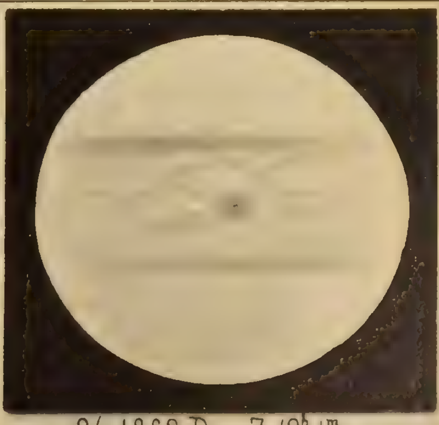
21. 1881 Dec. 27. $10^h 2^m$.



22. 1882 Jan. 17. $9^h 49^m$.



23. 1882 Dec. 7. $10^h 50^m$.



24. 1882 Dec. 7. $12^h 1^m$.

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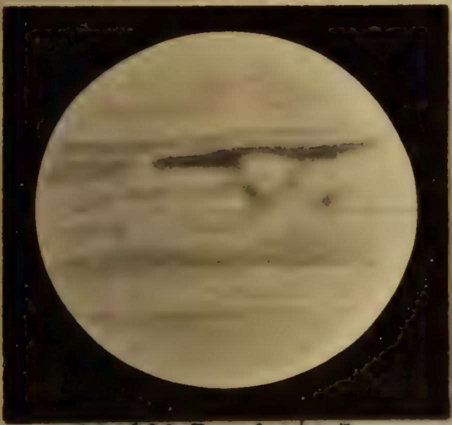
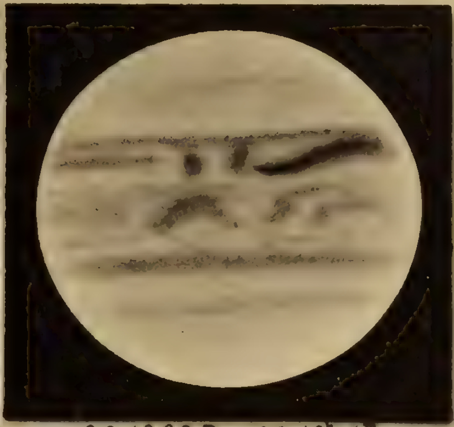
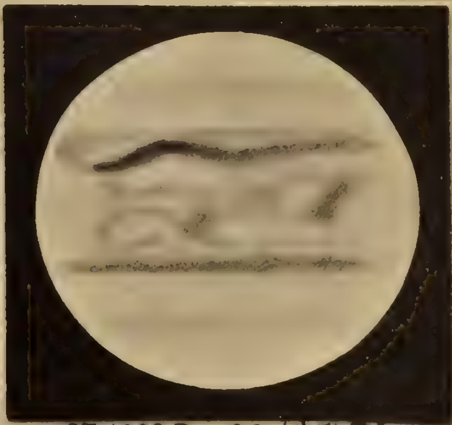


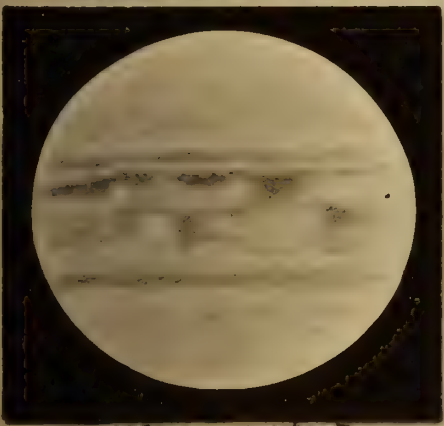
25. 1882 Dec. 8. 11^{h} 29^{m}.



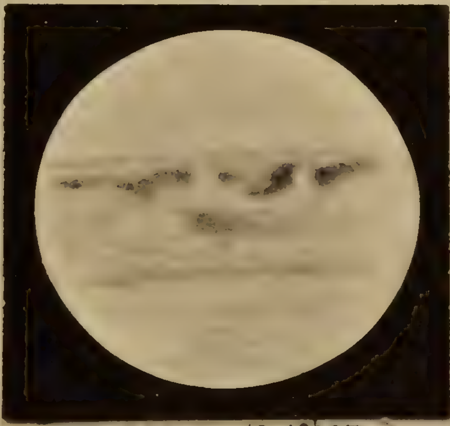
26. 1882 Dec. 22. 10^{h} 44^{m}.



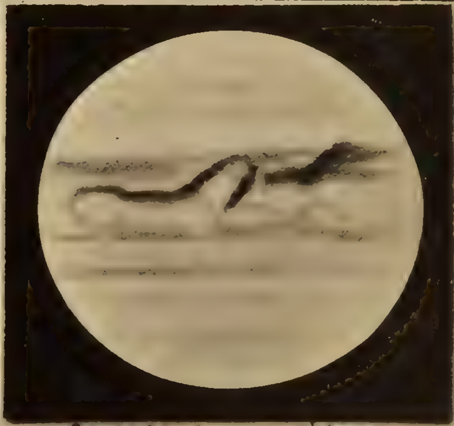
27. 1882 Dec 22. 11^{h} 54^{m} ?



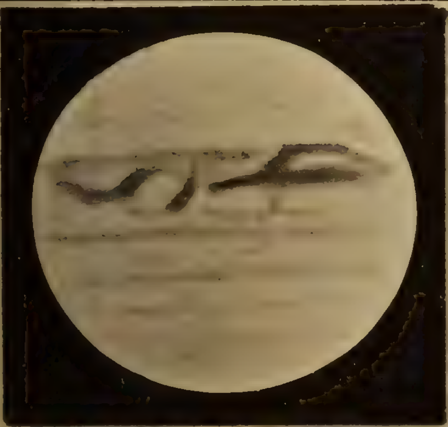
28. 1883 Jan. 15. 10^{h} 57^{m}.



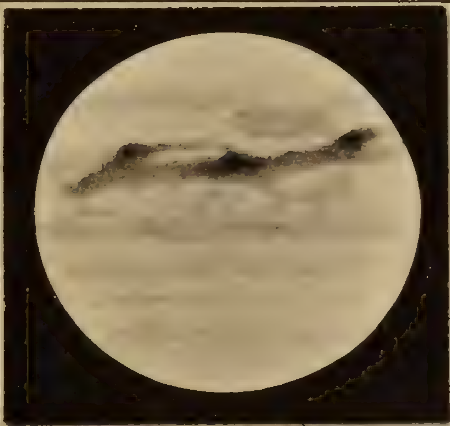
29. 1883 Jan. 15. 12^{h} 9^{m}.



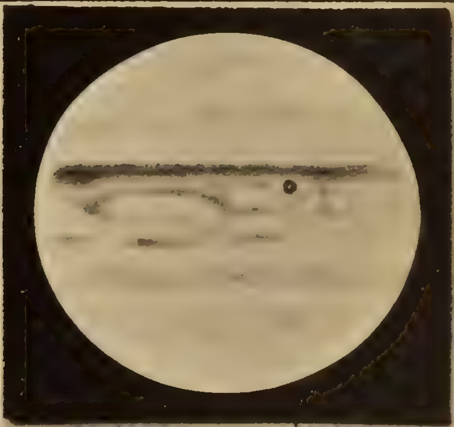
30. 1883 Jan. 18. 9^{h} 53^{m}.



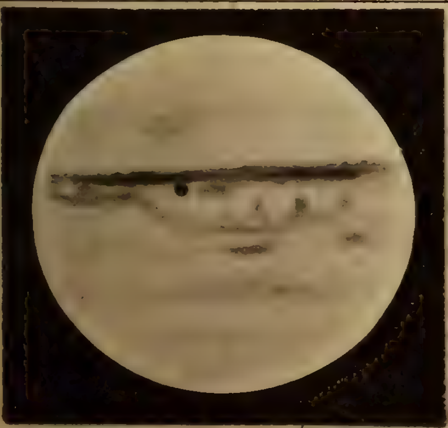
31. 1883 Jan. 18. 10^{h} 25^{m}.



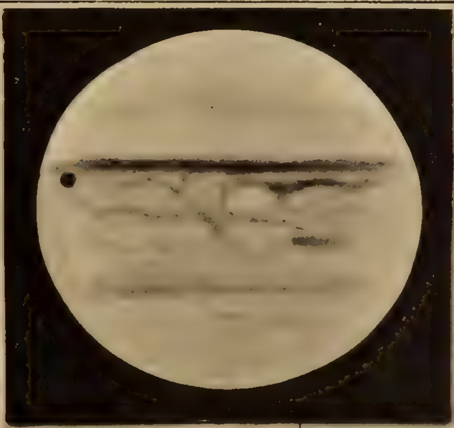
32. 1883 Jan. 18. 11^{h} 26^{m}.



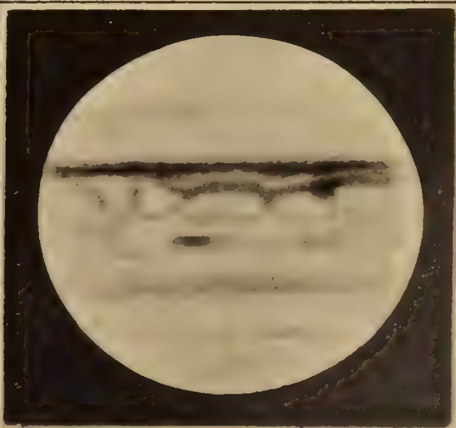
33. 1883 Jan. 19. 9^{h} 58^{m}.



34. 1883 Jan. 19. 10^{h} 35^{m}.



35. 1883 Jan. 19. 11^{h} 18^{m}.



36. 1883 Jan. 19. 11^{h} 59^{m}.

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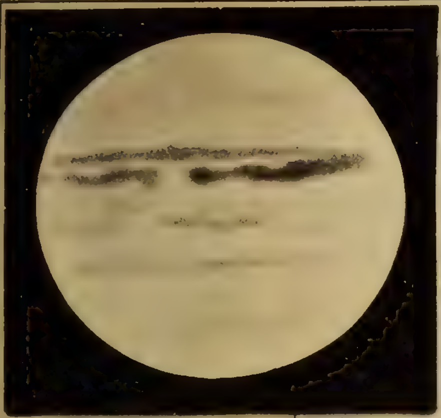
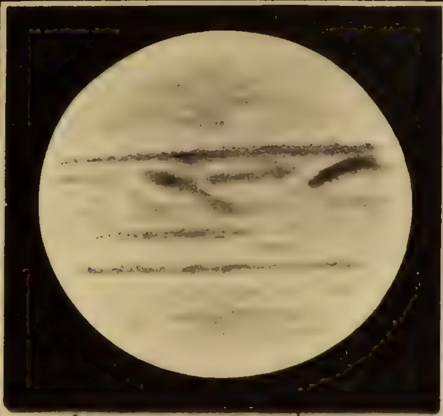
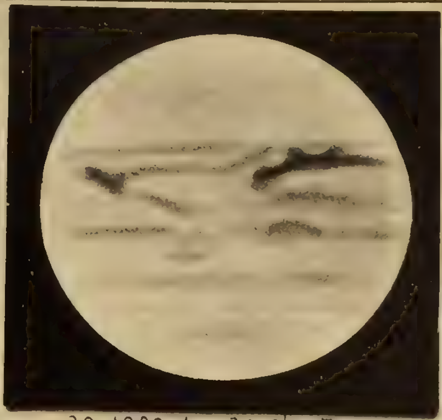
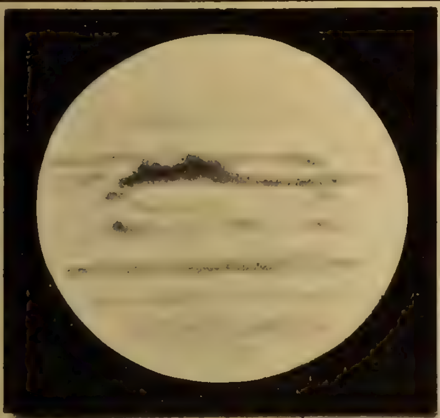
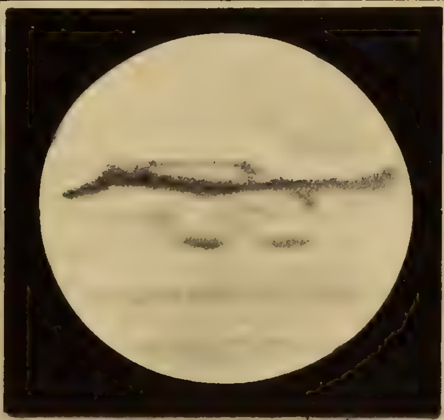
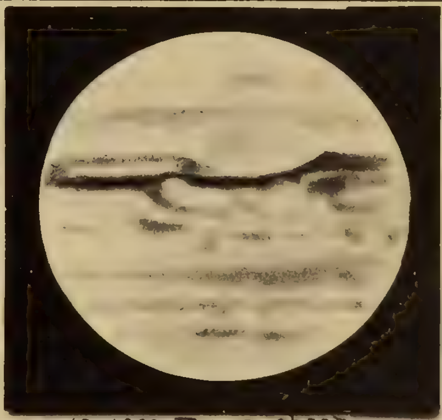

37 1883 Jan 27. $11^h 22^m$.


38. 1883 Jan 30. $8^h 44^m$.

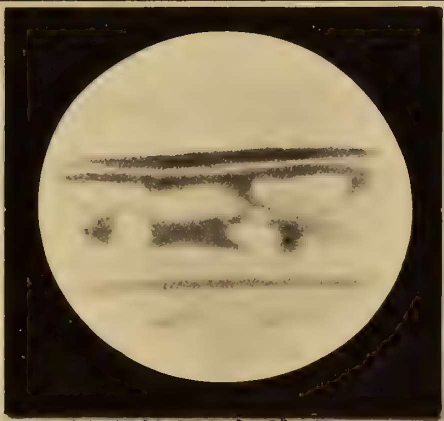

39. 1883. Jan. 30. $9^h 20^m$.

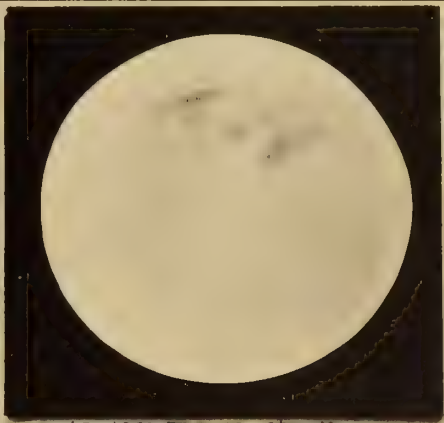

40. 1883 Jan. 30. $10^h 17^m$.


41. 1883 Jan. 30. $10^h 55^m$.

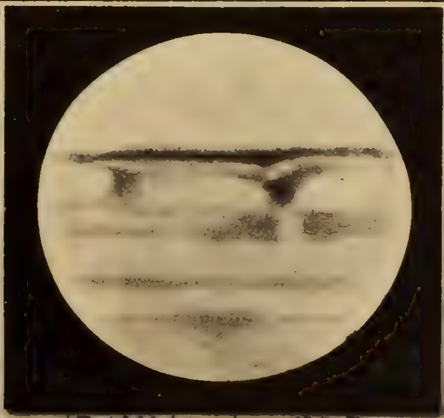

42. 1883 Feb. 2. $8^h 55^m$.

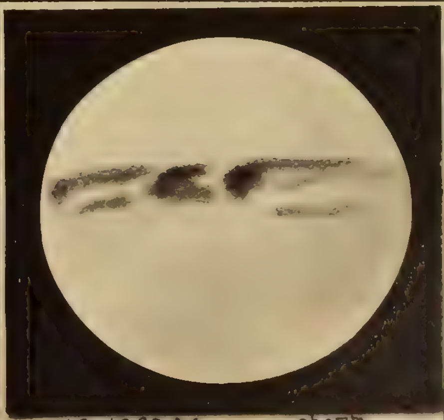

43. 1883 Feb. 2. $9^h 56^m$.


44. 1883 Feb. 3. $8^h 16^m$.


45. 1883 Feb. 13. $8^h 32^m$.


46. 1883 March 3. $7^h 54^m$.


47. 1883 March 4. $8^h 54^m$.


48. 1883 March 16. $9^h 37^m$.

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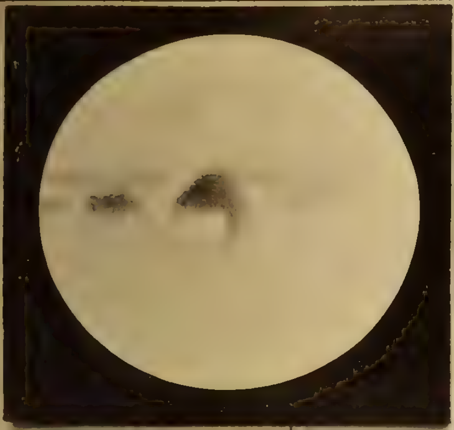
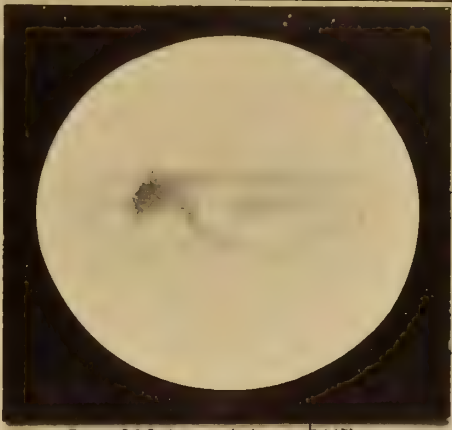
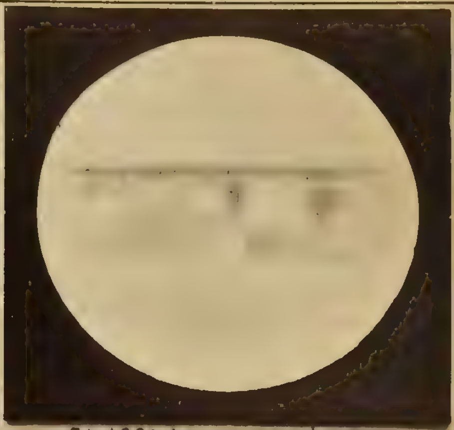
Wilh. Hoffmann imp. Dresden.



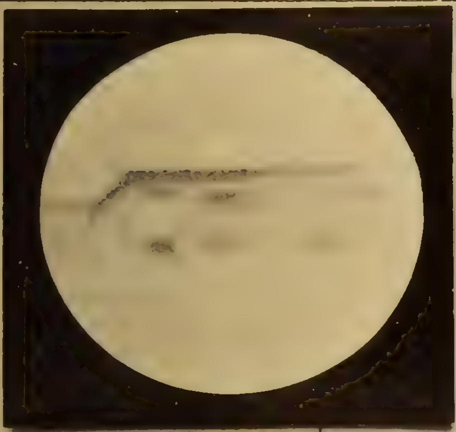
49. 1883 March 16 $9^{h} 58^{m}$.



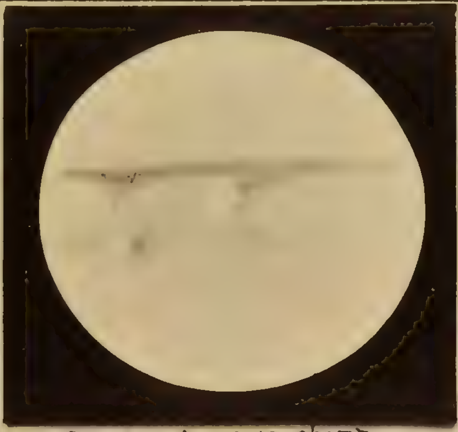
50. 1883 March 16. $10^{h} 21^{m}$.



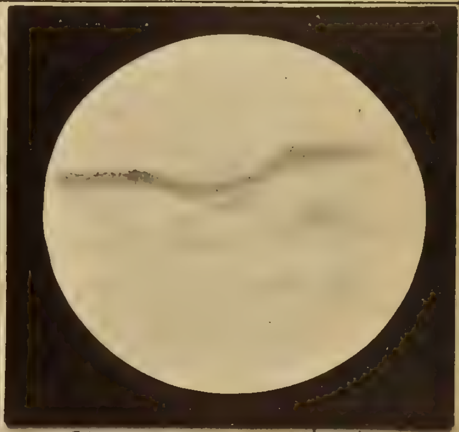
51. 1883 March 18. $9^{h} 24^{m}$.



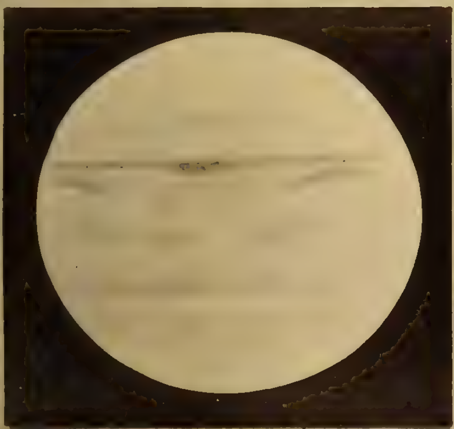
52. 1883 March 27 $9^{h} 22^{m}$.



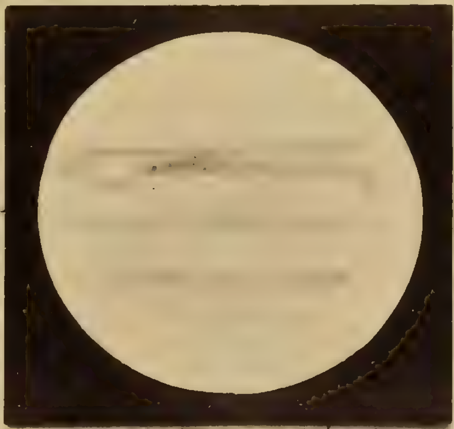
53. 1883 April 13. $9^{h} 37^{m}$.



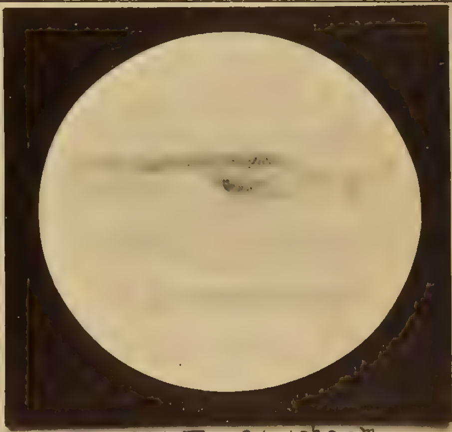
54. 1883 Nov. 13. $14^{h} 26^{m}$.



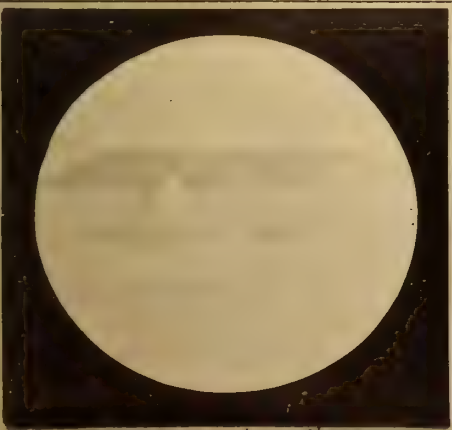
55. 1884 Feb. 24. $11^{h} 13^{m}$.



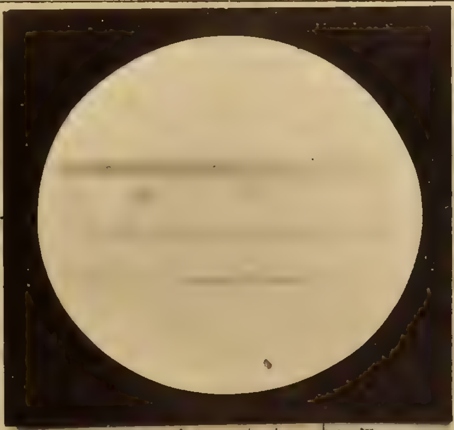
56. 1884 Feb. 24. $12^{h} 30^{m}$.



57. 1884 Feb. 24. $13^{h} 26^{m}$.



58. 1884 March 4. $8^{h} 25^{m}$.



59. 1884 March 4. $11^{h} 29^{m}$.

60. 1884 March 10. $9^{h} 21^{m}$.

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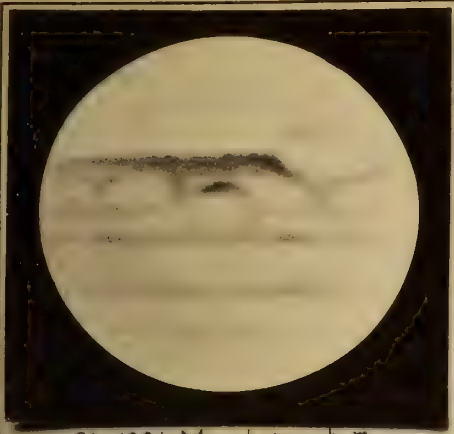
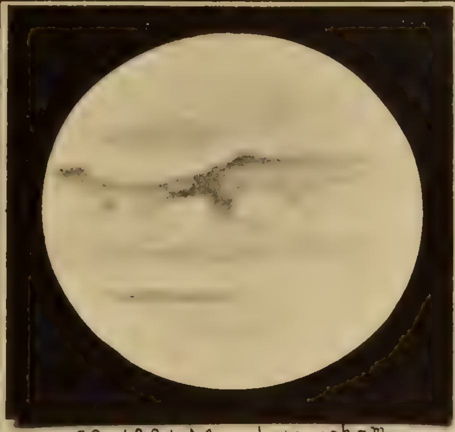
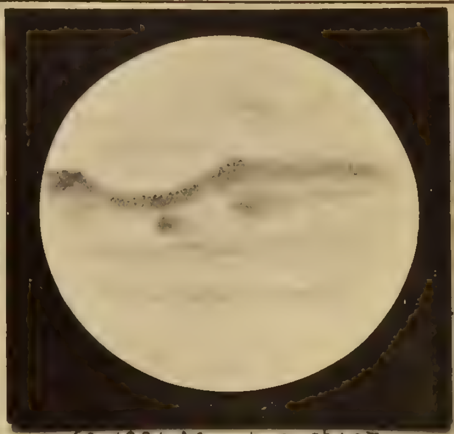
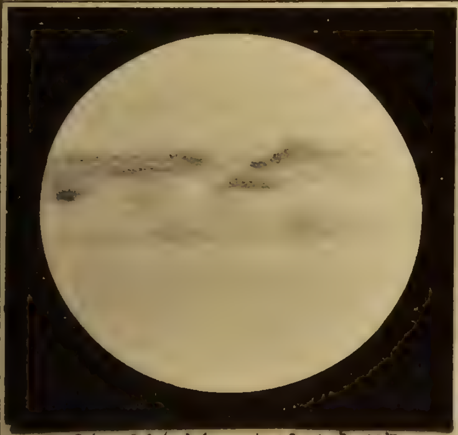
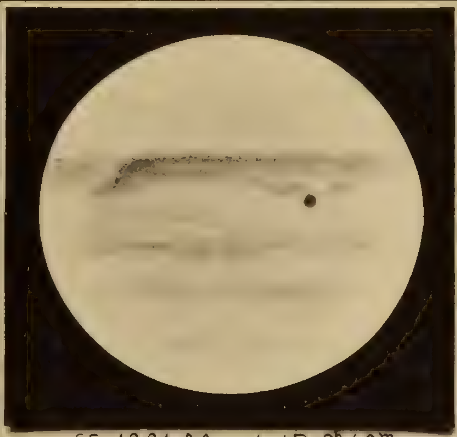
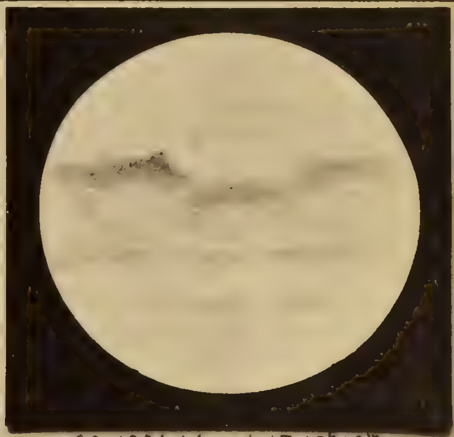

61. 1884 March 10. $11^h\ 1^m$

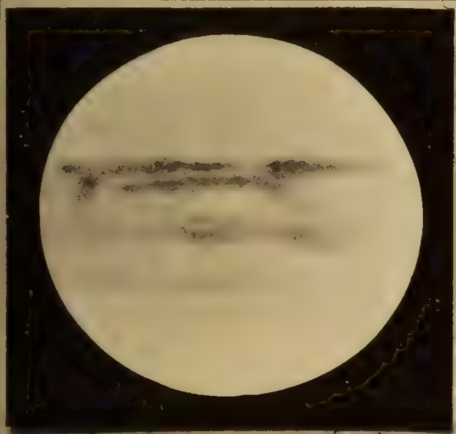

62. 1884 March 10. $12^h\ 5^m$.

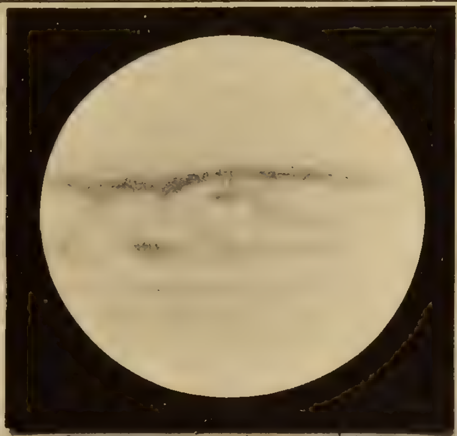

63. 1884 March 13. $9^h\ 42^m$.

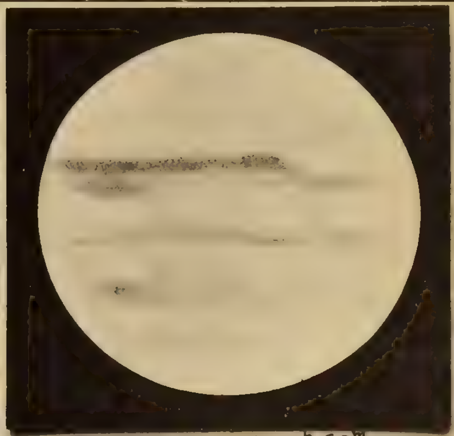

64. 1884 March 13. $11^h\ 17^m$.

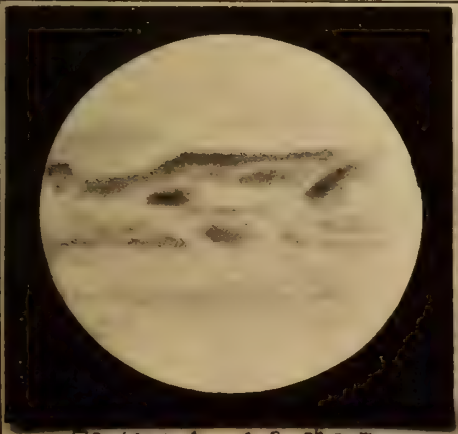

65. 1884 March 17. $9^h\ 48^m$.

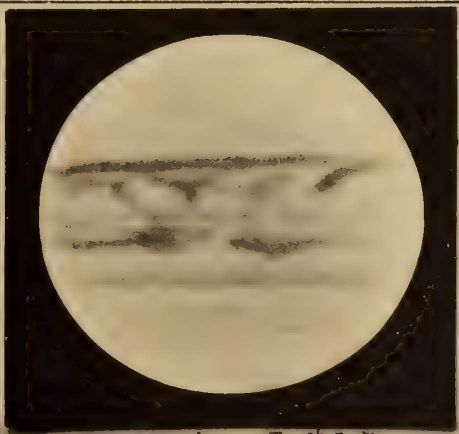

66. 1884 March 17. $12^h\ 18^m$.

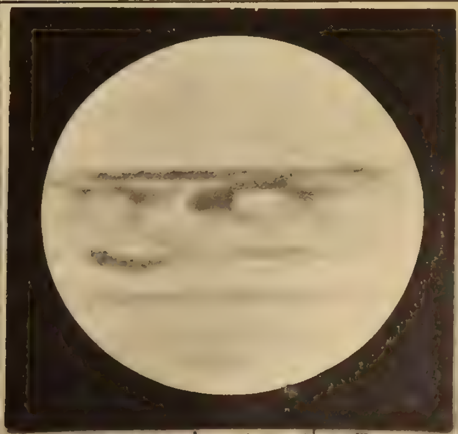

67. 1884 March 23. $9^h\ 43^m$.


68. 1884 March 23. $11^h\ 44^m$.


69. 1884 April 1. $8^h\ 52^m$.


70. 1884 April 6. $9^h\ 54^m$.


71. 1884 April 7. $8^h\ 50^m$.


72. 1884 April 7. $9^h\ 56^m$.

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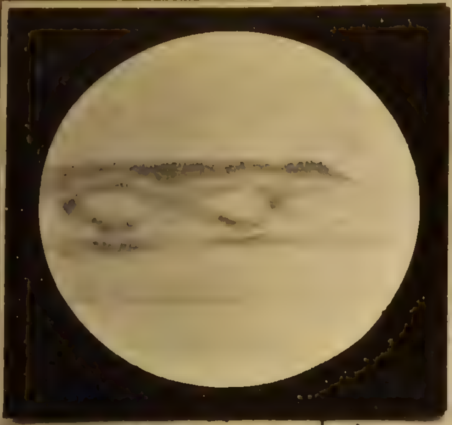
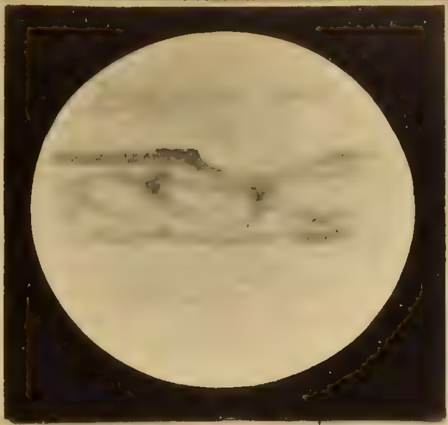
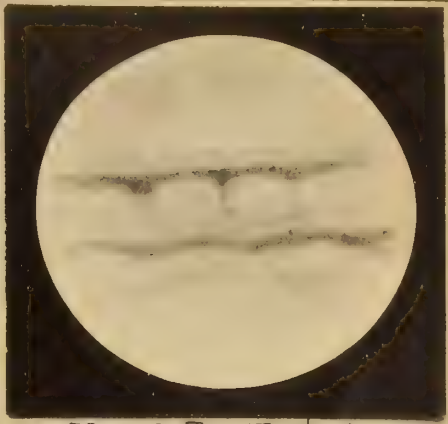


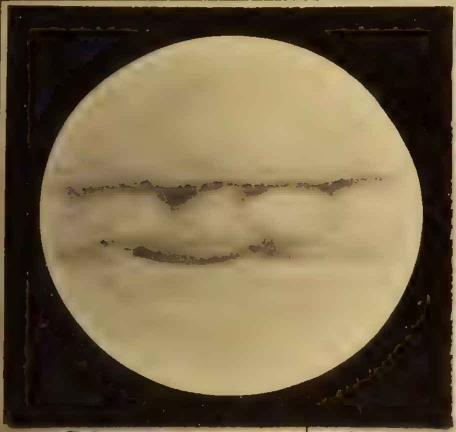
73. 1884 April 8. $9^h 14^m$.



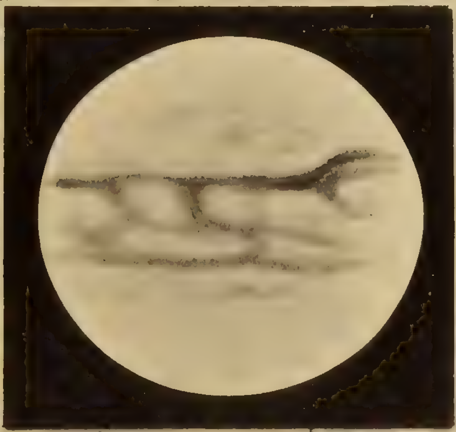
74 1884 April 8. $10^h 9^m$.



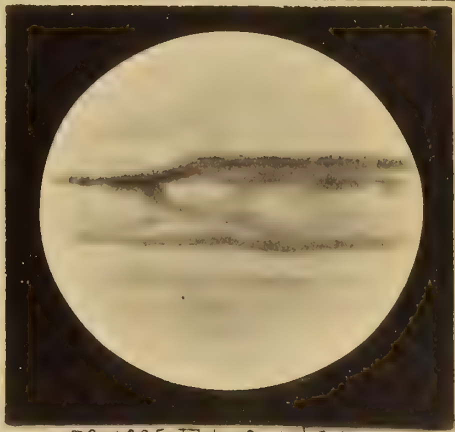
75. 1885 Feb. 17. $12^h 25^m$



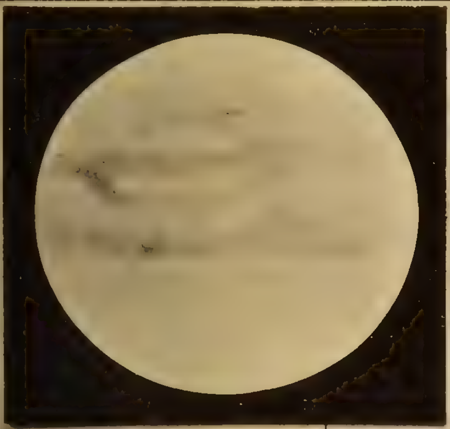
76. 1885 Feb. 17. $13^h 42^m$.



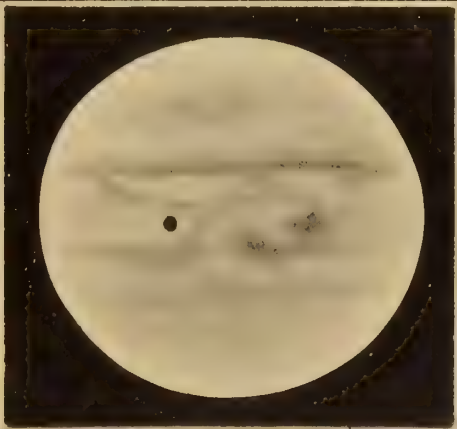
77. 1885 Feb. 18. $11^h 46^m$.



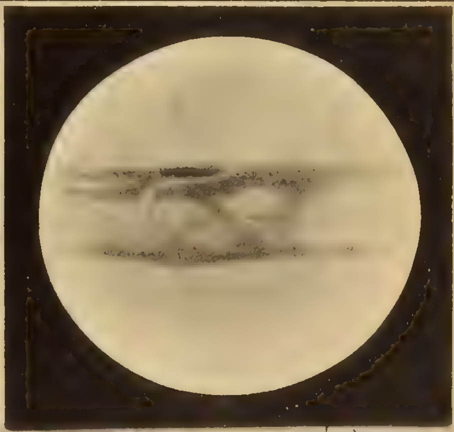
78. 1885 Feb. 18. $12^h 51^m$.



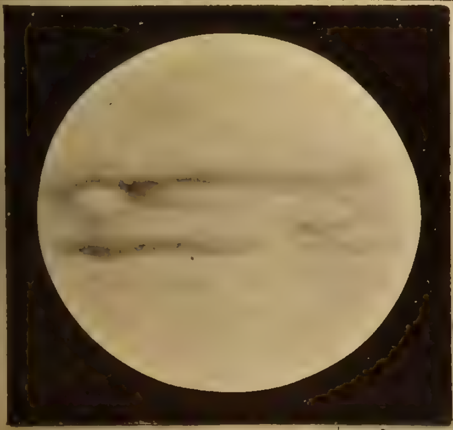
79. 1885 March 9. $12^h 39^m$.



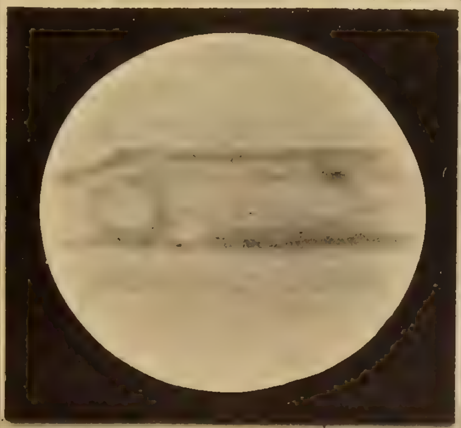
80. 1885 March 16. $10^h 20^m$.



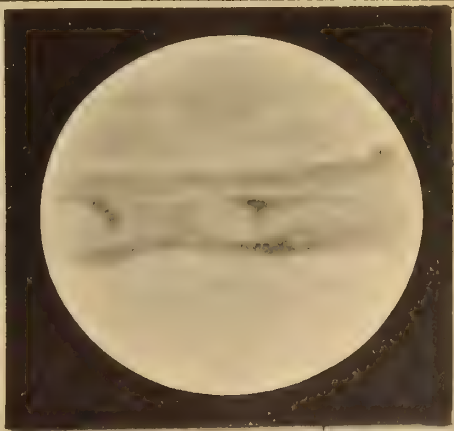
81. 1885 March 24. $12^h 9^m$.



82. 1885 March 24. $13^h 27^m$



83. 1886 March 6. $13^h 48^m$.



84 1886 March 13. $12^h 27^m$.

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IV.

A NEW DETERMINATION OF THE LATITUDE OF DUNSINK OBSERVATORY.

By ARTHUR A. RAMBAUT, M.A.

[Read November 14, 1888.]

The last determination of the latitude of Dunsink Observatory was made by Dr. Brünnow in the winter of 1873–74. His results were published in the *Fourth Part* of the *Dunsink Observations and Researches*, but have never been looked upon as more than provisional, and it has always been intended that a new determination of this quantity should be obtained whenever the Meridian Circle could be spared for the work.

Accordingly, in November of last year, I commenced a series of observations for this purpose on Polaris direct, and reflected from a basin of mercury. The observations were so arranged that at each culmination of the star two reflected observations were taken, then five direct, and then, again, three reflected.

This programme was carried out on each occasion, and in addition I obtained two readings of the nadir point of the circle before, and two after each transit of the star as a check on the result, although, of course, they were not necessary for the determination of the latitude.

In the year 1886 I had made a re-examination of the screws of the four microscopes on the western pier, which alone are used in observations of stars, and found the following formulæ for the corrections to be applied for their periodic errors :—

Microscope.	
V.	$+ 0''{\cdot}026 \cos(u + 17^\circ\ 45') + 0''{\cdot}088 \cos(2u + 74^\circ\ 14')$.
VI.	$+ 0\ {\cdot}234 \cos(u + 217\ \ 54\ ) + 0\ {\cdot}093 \cos(2u + 120\ \ 26\ )$.
VII.	$+ 0\ {\cdot}060 \cos(u + 75\ \ 30\ ) - 0\ {\cdot}095 \cos(2u + 0\ \ 36\ )$.
VIII.	$- 0\ {\cdot}116 \cos(u + 151\ \ 40\ ) + 0\ {\cdot}038 \cos(2u + 173\ \ 59\ )$.

The corrections computed from these formulæ are on the whole very similar to those determined in 1875, but are generally smaller, as if the screws had worn smooth during the eleven years which elapsed between the two determinations.

All the observations for latitude have been reduced with these values of the periodic corrections.

The correction (x) to the circle reading, for curvature and for the inclination of the horizontal wire of the telescope, has been computed from the following formulæ:—

$$x = -\sin^2\frac{(h-m)}{2}\sin 2\delta - \sin(h-m)\cos\delta\tan I \text{ for U. C. Direct.}$$

$$= +\sin^2\frac{(h-m')}{2}\sin 2\delta - \sin(h-m')\cos\delta\tan I \text{ ,, U. C. Reflected.}$$

$$= +\sin^2\frac{(h'-m)}{2}\sin 2\delta + \sin(h'-m)\cos\delta\tan I \text{ ,, L. C. Direct.}$$

$$= -\sin^2\frac{(h'-m')}{2}\sin 2\delta + \sin(h'-m')\cos\delta\tan I \text{ ,, L. C. Reflected.}$$

In these equations,

δ denotes the declination of the star.

I ,, the inclination of the horizontal wire.

h and h' denote the eastern and western hour angles, respectively, both being, in fact, the time of culmination *minus* the time of observation.

m denotes $b\cos\phi + k\sin\phi$.

m' ,, $-b\cos\phi + k\sin\phi$, b and k being the level and azimuth corrections, and ϕ the approximate latitude of the observatory.

It will be remarked that m and m' only differ with regard to the sign of b, which, for reflected observations, must be altered. Throughout this series of observations, however, both m and m' have been so small that it has not been necessary to take them into account. The second term also of the inclination, viz., $n\sin\delta\tan I$, on account of the small values of n and I, never amounted to as much as 0″005, and was therefore also negligible.

As the reticle of wires had been changed since the last determination of the inclination of the horizontal wire, it became necessary to obtain a new value for this quantity. This was derived from the observations of Polaris themselves, each culmination supplying two series of equations—one for the direct and one for the reflected observations—of the form,

$$C_0 + dC = C_1 + x.$$

In which C_1 is the circle reading when the hour angle is h (or h'),

C_0 is an assumed value of the circle reading at the time of culmination of the star, and

dC is a correction to be applied to C_0 to obtain the true circle reading.

From these equations the inclination was deduced by the method of least squares, and was found to be

$$I = -190''\cdot 4.$$

Employing this value then to reduce the whole series, and applying the necessary corrections for precession, nutation, and aberration, I find for the epoch 1888·0;—

ALTITUDE OF POLARIS.

	Upper Culmination.		Lower Culmination.
1887. Nov. 28,	54° 40′ 19″·63	1887. Dec. 11,	52° 6′ 7″·51
Dec. 19,	·33	,, 18,	6 ·95
,, 20,	·75	,, 19,	·97
,, 21,	·80	,, 20,	·95
1888. Jan. 5,	·70	,, 21,	·83
,, 9,	·57	1888. Jan. 8,	·30
,, 10,	·59	,, 9,	·59
,, 18,	·51	,, 18,	·83
,, 20,	·21		
,, 23,	·20		52° 6′ 6″·87 ± 0″·083
	54° 40′ 19″·53 ± 0″·046		

The mean of these results gives for the latitude of the meridian circle,

53° 23′ 13″·20 ± 0″·047.

Between January 5th and 8th, the position of the telescope was reversed, the clamp having been to the west up to then. If we separate the results before and after reversal, we find,

With clamp west, 53° 23′ 13″·34,

With clamp east, 53 23 13 ·00.

If we take only those days on which consecutive transits were observed, we have, Dec. 19th, 20th, and 21st, and Jan. 8th, 9th, and 18th available. These give

1887. Dec. 19,	53° 23′ 13″·15	
,, 20,	13 ·35	
,, 21,	13 ·31	
	53 23 13 ·27	with clamp west, and
1888. Jan. 8,	53° 23′ 12″·94	
,, 9,	13 ·09	
,, 18,	13 ·17	
	53 23 13 ·07	with clamp east.

The mean of these is 53° 23′ 13″·17—a result which is practically independent of the values of the precession and aberration adopted, as it is only necessary to correct for the effects which they produce in an interval of 12 hours. This result is almost identical with that obtained from the whole series, which may therefore be taken as the latitude of the meridian circle derived from observations of Polaris.

This result is still affected by any uncertainty which may attend the constant of refraction, and by the errors of the division lines used in the observations. The refractions were computed from the Greenwich Refraction Tables, and any error in the adopted value of the constant of refraction will affect the latitude by about three quarters of the amount of the error. With regard to the division errors, the close agreement of the results in the two positions of the instrument would seem to show that the division errors are not very large. It is, of course, possible that the errors on the two circles might act in the same direction, but the fact that Dr. Brünnow's results, obtained with the same instrument and same method of observing, differ in the opposite direction, viz.:

Clamp west,	53° 23′ 13″·14,
Clamp east,	14 ·08,

renders it unlikely that this is the case.

On account of this uncertainty with regard to the division errors of the circles, I have, following Dr. Brünnow's example, computed the latitude from a number of stars culminating at various zenith distances. These stars were not observed directly with a view to the purpose, but in the course of my ordinary work. They are all taken from Auwer's *Fundamental Catalogue*, the adopted values of their declinations being those of the *Berliner Jahrbuch.* They may be divided into two

groups—those observed in 1887 and those observed in 1888. The following is a complete list of them :—

1887.

Date.	Clamp.	Star.	Zen. Dist.	Latitude.	Date.	Clamp.	Star.	Zen. Dist.	Latitude.
June 7.	W.	ξ Draconis, .	− 3° 30′	53° 23′ 12″·35	Sept. 16.	E.	β Ceti, . .	+ 71° 56′	53° 23′ 10″·12
		μ Herculis, .	+ 25 35	11 ·60			θ Ceti, . .	+ 62 7	11 ·31
June 8.		μ Herculis, .	+ 25 35	10 ·88	Sept. 19.	W.	3 Lacertæ, .	+ 1 43	12 ·53
		ξ Draconis, .	− 3 30	11 ·32			Br. 3077, . .	− 3 10	13 ·26
July 15.		θ Serpentis p.,	+ 49 18	13 ·30			α Andromedæ,	+ 24 54	12 ·67
		δ Aquilæ, .	+ 50 28	13 ·79	Sept. 23.		α Pegasi, . .	+ 38 46	12 ·19
		ψ Cygni, . .	+ 1 15	13 ·75			Br. 3077, . .	− 3 10	12 ·20
July 22.		32 Vulpeculæ,	+ 25 45	12 ·76			γ Pegasi, . .	+ 38 49	12 ·13
		74 Cygni, . .	+ 13 28	11 ·57	Oct. 11.		ο Andromedæ,	+ 11 39	12 ·84
Aug. 10.	E.	κ Cygni, . .	+ 0 13	13 ·21	Oct. 14.		ω Piscium, .	+ 47 8	12 .34
		ο′ seq. Cygni,	+ 6 59	13 ·63			ο Cassiopeæ, .	+ 5 43	13 ·16
Aug. 26.		β Delphini, .	+ 39 10	12 ·87	Oct. 24.		β Andromedæ,	+ 18 21	12 ·14
		10 Lacertæ, .	+ 14 55	13 ·71			υ Persei, . .	+ 5 20	12 ·39
		κ Piscium, .	+ 52 44	13 ·76	Nov. 18.		ω Piscium, .	+ 47 8	11 ·80
Sept. 7.		16 Pegasi, . .	+ 27 59	11 ·38			β Andromedæ,	+ 18 21	11 ·75
		α Andromedæ,	+ 24 55	12 ·98					

Mean for 1887, . . 53° 23′ 12″·44 ± 0″·11.

1888.

Date.	Clamp.	Star.	Zen. Dist.	Latitude.	Date.	Clamp.	Star.	Zen. Dist.	Latitude.
Sept. 5.	W.	ε Piscium, .	+ 46° 5′	53° 23′ 12″·86	Sept. 12.		41 Arietis, .	+ 26° 35′	53° 23′ 13″·00
		η Piscium, .	38 36	13 ·04	Sept. 16.		ε Piscium, .	46 5	11 ·74
		μ Ceti, . .	43 44	13 ·19			η Piscium, .	38 36	12 ·11
		41 Arietis, .	26 35	12 ·24			41 Arietis, .	26 35	12 ·12
Sept. 7.		ε Piscium, .	46 5	13 ·07			α Ceti, . .	49 43	13 ·31
		η Piscium, .	38 36	13 ·02	Oct. 4.		ε Piscium, .	46 5	13 ·15
		μ Ceti, . .	43 44	12 ·77			η Piscium, .	38 36	12 ·68
		α Ceti, . .	49 43	13 ·49			ο Piscium, .	44 46	13 ·07
Sept. 12.		ε Piscium, .	46 5	12 ·81			41 Arietis, . .	26 35	13 ·50
		η Piscium, .	38 36	12 ·46			α Ceti, . .	49 43	14 ·00
		α Triang., .	24 21	12 ·78					

Mean for 1888, . . 53° 23′ 12″·88 ± 0″·08.

In consequence of the considerable discrepancies between these values for the latitude, I have grouped them according to zenith distances in zones of 5° in width, with the following result:—

Star.	Zen. Dist.	Latitude.
0° – –5°.		
ξ Draconis, . .	– 3° 30′	53° 23′ 13″·35
,, . . .	– 3 30	11 ·32
Br. 3077, . .	– 3 10	13 ·26
,, . . .	– 3 10	12 ·20
	– 3 20	12 ·53
0° – + 5°.		
ψ Cygni, . . .	+ 1 15	13 ·75
κ Cygni, . . .	0 13	13 ·21
3 Lacertæ, . .	1 43	12 ·53
	+ 1 4	13 ·16
+ 5° – + 10°.		
o′ Seq Cygni, . .	+ 6 59	13 ·63
o Cassiopeæ, . .	5 43	13 ·16
υ Persei, . . .	5 20	12 ·39
	+ 6 1	13 ·06
+ 10° – + 15°.		
74 Cygni, . . .	+ 13 28	11 ·57
10 Lacertæ, . .	14 55	13 ·71
o Andromedæ, .	11 39	12 ·84
	+ 13 21	12 ·71
+ 15° – + 20°.		
β Andromedæ, .	+ 18 21	12 ·14
,, . .	+ 18 21	11 ·75
	+ 18 21	11 ·19
+ 20° – + 25°.		
α Andromedæ, .	+ 24 55	12 ·98
,, . .	24 55	12 ·67
α Triang., . . .	24 21	12 ·78
	+ 24 44	12 ·81
+ 25° – + 30°.		
μ Herculis, . .	+ 25 35	11 ·60
,, . .	25 35	10 ·88
32 Vulpeculæ, . .	25 45	12 ·76
16 Pegasi, . . .	27 59	11 ·38
41 Arietis, . . .	26 35	12 ·24
+ 25° – + 30°.		
41 Arietis, . . .	+ 26° 35′	53° 23′ 13″·00
,, . . .	26 35	12 ·12
,, . . .	26 35	13 ·50
	+ 26 24	12 ·19
+ 35° – + 40°.		
β Delphini, . .	+ 39 10	12 ·87
α Pegasi, . . .	38 46	12 ·19
γ Pegasi, . . .	38 49	12 ·13
η Piscium, . . .	38 36	13 ·04
,, . . .	38 36	13 ·02
,, . . .	38 36	12 ·46
,, . . .	38 36	12 ·11
,, . . .	38 36	12 ·68
	+ 38 43	12 ·56
+ 40° – + 45°.		
μ Ceti, ...	+ 43 44	13 ·19
,, ...	43 44	12 ·77
o Piscium, . . .	44 46	13 ·07
	+ 44 5	13 ·01
+ 45° – + 50°.		
θ Serpentis p., .	+ 49 18	13 ·30
ω Piscium, . . .	47 8	12 ·34
,, . . .	47 8	11 ·80
ε Piscium, . . .	46 5	12 ·86
,, . . .	46 5	13 ·07
,, . . .	46 5	12 ·81
,, . . .	46 5	11 ·74
,, . . .	46 5	13 ·15
α Ceti, . . .	49 43	13 ·49
,, . . .	49 43	13 ·31
,, . . .	49 43	14 ·00
	+ 47 33	12 ·90
+ 50° – + 55°.		
δ Aquilæ, . . .	+ 50 28	13 ·79
κ Piscium, . . .	52 44	13 ·76
	+ 51 36	13 .77

I have here omitted the observations of Sept. 16th, 1887, as they were made under very unfavourable circumstances.

An inspection of these figures shows that the observed values of the latitude diminish pretty steadily down to about 20° or 30° zenith distance, and from this point they begin to increase again. I have therefore supposed the discrepancies to be due to the flexure of the instrument, and attempted to represent it by an expression of the form of

$$f \sin z + g \cos z,$$

so that each of the means given above supplies us with an equation of the form

$$\Delta\phi + f \sin z_1 + g \cos z_1 = \phi_1 - \phi_0 = n_1,$$

in which ϕ_1 is the observed, and ϕ_0 the adopted value of the latitude, and $\Delta\phi$ the correction to the latter, while z_1 is the zenith distance. I have taken $\phi_0 = 53° \; 23' \; 13''\cdot 00$, and weighting the equations according to the number of observations upon which each depends, I find

$$\Delta\phi = + 5''\cdot 64,$$
$$f = - 2 \cdot 39,$$
$$g = - 5 \cdot 86.$$

These values being quite inadmissible, this result shows that the discrepancies between the different means is not due to a flexure error of the form given above, nor are the observations numerous or accurate enough to attempt a determination of the terms containing higher multiples of z.

This being the case, it appeared to me that it would be of interest to compare the mean of the results for the stars of south zenith distance observed in 1888, with the result obtained from the direct observations of Polaris combined with the nadir point of the circle, the mean zenith distance of the former being almost the same as that of Polaris.

For this purpose I have to reject the observations of Polaris on Dec. 11th and on Jan. 20th, as on neither occasion were the observations of the nadir-point satisfactory. I thus obtain from the other observations :—

ALTITUDE OF POLARIS AT UPPER CULMINATION.

	Direct.	Reflected.		Direct.	Reflected.
1887. Nov. 28,	54° 40′ 19″·04	54° 40′ 20″·22.	1888. Jan. 9,	54° 40′ 19″·99	54° 40′ 19″·15.
Dec. 19,	18 ·83	19 ·83.	,, 10,	19 ·91	19 ·28.
,, 20,	19 ·18	20 ·32.	,, 18,	18 ·95	20 ·07.
,, 21,	19 ·80	19 ·80.	,, 23,	19 ·07	19 ·33.
1888. Jan. 5,	19 ·69	19 ·70.			

ALTITUDE OF POLARIS AT LOWER CULMINATION.

	Direct.	Reflected.		Direct.	Reflected.
1887. Dec. 18,	52° 6′ 6″·16	52° 6′ 7″·73.	1888. Jan. 8,	52° 6′ 6″·94	52° 6′ 5″·67.
,, 19,	6 ·26	7 ·67.	,, 9,	6 ·71	6 ·48.
,, 20,	6 ·64	7 ·26.	,, 18,	6 ·69	6 ·96.
,, 21,	6 ·20	7 ·46.			

We thus obtain,

		Direct.	Reflected.
Cl. W.	U. C.	54° 40′ 19″·31	54° 40′ 19″·99
	L. C.	52 6 6 ·31	52 6 7 ·53
Cl. E.	U. C.	54 40 19 ·48	54 40 19 ·46
	L. C.	52 6 6 ·78	52 6 6 ·27

And for the different values of the latitude—

	Direct.	Reflected.
Clamp W.,	53° 23′ 12″·81	53° 23′ 13″·76
Clamp E.,	13 ·13	12 ·87

We thus see that the value of the latitude derived from the direct observations of Polaris, with clamp west, is almost identical with that derived from the southern stars of nearly the same mean zenith distance, and in the same position of the instrument—the seconds, in the former case being 12″·81, and in the latter 12″·88. This would lead us to suppose that the flexure was exceedingly small, and a comparison of the results derived from direct and the reflected observations of Polaris, in the two positions of the instrument, would lead to the same conclusion.

Which of these various results shall we adopt?

It appears to me that the mean of the result derived from the whole series of observations of Polaris, and that derived from the observations of the *Berliner Jahrbuch* stars, will probably give us the best value of the latitude—the former being free from flexure, but affected by division errors, and the latter practically free from division errors, but still affected by flexure and any errors which may exist in the adopted declination of the stars.

The mean of these results, weighting them according to the number of observations upon which each depends, is

$$53^\circ\ 23'\ 13''\cdot08 \pm 0''\cdot04.$$

Dropping the second decimal, therefore, I conclude that until the division errors of the individual lines on the circles have been determined, as accurate a value of the latitude of the meridian circle as can be hoped for, is

$$53^\circ\ 23'\ 13''\cdot1.$$

V.

A REVISION OF THE BRITISH ACTINIÆ. PART I. By ALFRED C. HADDON, M. A. (Cantab.), M.R.I.A., Professor of Zoology, Royal College of Science, Dublin. Plates XXXI. to XXXVII.

[Read June 13, 1888.]

This is the first of what I hope will be a series of communications to the Royal Dublin Society on the Sea Anemones of the British seas. Thanks to the labours of such naturalists as Mr. George Johnston, Professor Edward Forbes, Sir John Dalyell, Mr. R. Q. Couch, and many others, but most especially to those of Mr. P. H. Gosse, we have a very complete knowledge of the appearance and habits of the Actiniæ found round our shores. In scarcely any country is the Actinian fauna so well described and figured as that in our own.

In classifying the Actiniæ external characters were alone formerly considered; but of recent years attention has been drawn to internal structure as a basis for classification. It is to the brothers Hertwig that the credit of the new departure is mainly due, and more particularly to Dr. Richard Hertwig, who, in his masterly "Report on the Actiniaria" dredged by H. M. S. "Challenger," has laid down broad lines of Actinian taxonomy, which, being based on morphology, are more strictly scientific than the systems of Prof. H. Milne Edwards, Mr. Gosse, Prof. Verrill, or Dr. Andres.

The time has now arrived when it is advisable and possible to revise the British Actiniæ. Not a few of the genera and species found around the coasts of Europe have been described from British specimens; but, apart from external characters, we are unable to assign to most of them a position in the groups proposed by Prof. R. Hertwig, on account of the absence of any knowledge of their anatomy. It is to take away this reproach that I have attempted a revision of the British Actiniæ, of which the present is a first contribution.

Considerable confusion has unnecessarily been made in the synonymy of the Actiniæ, owing to the generally recognised rules of zoological nomenclature being too often ignored. In the course of this revision I have found it necessary to

adopt several generic and specific names, which have been rarely used by zoologists, in the place of very well-known names—for example, *Tealia crassicornis* (O. F. Müll.) becomes *Urticina felina* (Linn.), and *Sagartia* (*Heliactis*) *bellis* (Ellis and Sol.) must be known as *Cereus pedunculatus* (Penn). I have done this with great reluctance, as it is not easy to remember the scientific names of animals when they are being continually changed; and, further, superfluous change in nomenclature is very objectionable from a faunistic and museum point of view; the latter, however, need hardly be considered in the present instance, as few museums possess any Actiniæ at all.

Not only has simple priority been ignored, but new names have sometimes been given, even when the introducer of the new name was aware of the pre-existing names.

In a few instances an old name has been misapplied to a species when the recorder had no knowledge that it was the same species. This error has occasionally been fallen into because the published description of the older naturalists were usually somewhat vague, so that the description might very well apply to more than one species. It is only by the recovery of the lost type and its re-description that such unavoidable errors can be rectified. But again, confusion is made when a zoologist assumes, without sufficient proof, that his specimen, possibly only known in the preserved state, is the same species as that previously described from living forms, captured, perhaps, thousands of miles distant. This action, instead of having the desired effect of simplifying classification, adds to its confusion, as it is always much easier to unite species together than to split up a species. If any doubt exists it is far better to describe the species as new, and to leave its amalgamation with previously described species to one who has a personal knowledge of that species, than to beg the question, and, by assuming an identity, to run the risk of giving false anatomical characters to an old species.

When an author has diagnosed a new genus, and named a species as its type, these names should thenceforth be inseparably connected, unless priority has been infringed. It is the ignoring of this recognised rule which has largely complicated Actinian nomenclature.

For the mere naming of specimens, a trained eye, an acquaintance with the bibliography, and an appreciation of the rules for zoological nomenclature, are alone necessary. For the classification of the genera and species it is requisite to have a fairly minute knowledge of their anatomy. Mere reliance upon outward form or external characters has led to essentially dissimilar forms being associated together. A rational scheme of classification must also take the development of the individual into account. Thus, while the name of an animal may be determined by the collector or museum curator, these must accept the classification suggested by the comparative anatomist and embryologist. Once the taxonomy is

established, the most easily ascertained characters, even if they are of trivial importance, are all that are necessary for determining purposes. The separation of the methods of systematic zoologists and those of structural zoologists has been the fruitful cause of complication in nomenclature.

In the following descriptions I have to classify the Actiniæ referred to from an anatomical standpoint; but, at the same time, external characters of both living and preserved specimens have not been ignored. Preserved Actiniæ are peculiarly difficult to determine: with increased knowledge a great deal may be done, but in many cases the task will probably always remain hopeless, unless notes on form and colour have been taken of the living animal.

In the following pages it will be seen that the species of the genera Edwardsia and Halcampa, which have already been examined, can readily be distinguished by certain anatomical details, as, for instance, the pattern of the longitudinal retractor muscles of their mesenteries. On the other hand, the three species of the genus Sagartia, *s.s.*—*S. miniata*, *S. venusta*, and *S. nivea*, cannot at present be distinguished anatomically. A possible explanation is not far to seek. From their general structure we may confidently assert that Edwardsia and Halcampa are old genera, as they retain, in their adult state, features which are transiently present in the young of the more typical Actiniæ. We may therefore assume that the existing species of this genera are well established, and have remained constant for a sufficient period for the acquisition of definite structural characters. The genus Sagartia is more specialized, and it is open to us to suppose that the species have not yet got beyond the stage of colour differentiation.

Parallel cases can be found in almost every group of animals where the species of one genus are easily defined, whereas in another genus the specific distinctions have reference to the presence or absence of a particular spot or marking.

In order to establish actinological studies on a sure foundation it will be necessary first of all to recover the types. The most satisfactory way to accomplish this is to go to the original locality and collect specimens there. Then, having recovered it, the type must be subjected to anatomical investigation. Its place in the system of Actiniæ will then be accurately known, and not till then. There has been up to the present a great deal too much of guess-work in this group.

I have found it necessary to introduce a few new terms, in order to indicate certain mesenteries and the chambers between them. In adult forms an axial line is always recognisable, but beyond that, in the majority of Actiniæ there is a radial symmetry. It has long been known that the larval forms of all Actiniæ hitherto studied are bilaterally and not radially symmetrical, and a definite orientation is possible for these, and for some adults, as I shall subsequently

show. The new terms I propose have relation to this primitive bilateral symmetry.

I have shown elsewhere (**1887**, p. 473*) that the larval Halcampa possesses a single deep œsophageal groove. I have reason to believe that the remarkable groove in Peachia occurs at the same angle of the œsophagus in that genus. The single œsophageal groove of the Zoantheæ has the same relations. I therefore take this as the more important groove, and speak of it as the "sulcus:" the less important opposite groove is the "sulculus."

The sagittal œsophageal grooves were named by Mr. Gosse the "gonidial grooves" (*canales gonidiales*) (**1860**, p. 4). He did not distinguish between them. Dr. Andres (**1884**, p. 73) adopts the terms *gonidium* and *gonidulum.* It may be considered that it is unnecessary to coin new terms with these before us; but they do not readily lend themselves to combination with others. The brothers Hertwig distinguished these grooves as "dorsal" and "ventral." This is an unfortunate application of terms which have a false significance in our group. We may speak of organs as "lateral" to a given axial line, but the words "dorsal" and "ventral" have no meaning, except a misleading one, for the Actiniæ. The sulcar directive mesenteries correspond with the "ventral" of the German authors, and the sulcular with the dorsal. Dr. Hickson (**1883**, p. 693) has introduced the term "siphonoglyphe" for the ciliated axial groove of Alcyonarians, in which group it is now universally accepted. It is, however, not conveniently applicable to the Actiniæ. The terms "axial" and "abaxial," as used by Prof. A. Milnes Marshall (**1883**, p. 125), for Pennatula, have express relation to the axis of the polypdom, as Dr. Marshall speaks of the "inner or axial," and the "outer or abaxial," surfaces. These terms are clearly unsuitable for Actiniæ.

In adult Actiniæ with two œsophageal grooves it is not possible to distinguish which is the sulcar and which is the sulcular groove; nor when only one groove is present can we in all cases determine which it is. Probably it will be found that, in every case where one groove only is present during the whole of life, it is the sulcar groove. But in the case of the genus Sagartia (Gosse, *s. s.*), one groove is as often present as two. There is no reason, as far as is known, to regard this as the sulcus. It appears to be more probable that the one-grooved condition is a secondary feature, and the groove may be either the sulcus or the sulculus. When it is impossible to determine the homology of the groove or grooves, I shall simply term them œsophageal grooves.

* In referring to the bibliography which is appended to this Revision, I have adopted the plan introduced by Dr. E. L. Mark, of Harvard, by which the reference number gives the reader the approximate date of the article.

In addition to the sagittal grooves lateral furrows may or may not be present; they are of no morphological importance.

The whole endodermal cavity has been appropriately termed the cœlenteron; it is divided radially by the mesenteries into chambers. I have adopted Mr. Fowler's (**1885**, p. 578) terms of "endocœle" for an intra-mesenterial chamber, and "exocœle" for an inter-mesenterial chamber. The endocœles of the directive mesenteries are respectively the sulcar endocœle and the sulcular endocœle. The combinations used to designate the various chambers of the ground-type are given in the last section of this communication.

The use of the term "septa" instead of "mesenteries" for the radial partitions of the cœlenteron is to be strongly deprecated, owing to the universal acceptance of that word for the radial calcareous plates of the Madreporaria.

Mr. Bourne's (**1887**, p. 311) term, "mesoglœa," bids fair to be generally adopted. It conveniently replaces the term "mesoderm," which is open to serious objection, and such cumbersome names as "supporting membrane" or the like.

A word of personal explanation is necessary. I had hoped to be able to deal with the subject in something approaching to a logical method; but two circumstances have prevented this: the first is the difficulty which exists in procuring specimens of many of the species. If completed work on available specimens was retarded in publication until other species or genera were obtained, the results attained would long lie dormant. In the second place, I am leaving Ireland for some time, and it may be a considerable period before I shall be able to conclude this series of Papers. I shall not even have the opportunity of reading the proofs of this Memoir. Thus, at present, I am only in a position to give an approximately complete account of one group of the Actiniæ—the Chondractininæ; in another section of this Paper I deal with a variety of genera, all of which, however, may be regarded as more or less representing the various stages in the evolution of the typical hexameral Actiniæ.

The family Sagartidæ was first thus defined by Mr. Gosse (**1858**, p. 415): "Sagartiadæ [this is the form of spelling adopted, and adhered to, by Mr. Gosse]. Basis adhærens. Tentacula simplicia, in cyclis continuis digesta. Cutis, pro filis retractilibus armatis emittendis, perforata." It included the genera Actinoloba (*A. dianthus*) and Sagartia, the latter being thus diagnosed: "Basis integra, cyclica. Tentacula libenter et totaliter retractilia. Cutis acetabulis instructa. Os duabis canalibus gonidialibus instructum" with the following species: *S. bellis*, *S. miniata*, *S. rosea*, *S. ornata*, *S. ichthyostoma*, *S. venusta*, *S. nivea*, *S. sphyrodeta*, *S. pallida*, *S. pellucida*, *S. coccinea*, *S. troglodytes*, *S. viduata*, *S. parasitica*. Although the title-page of the "Actinologia Britannica" bears the date of 1860, the book was issued in bi-monthly parts, of which the first (pp. 1–32) was issued, as dated, on March 1st, 1858; consequently the fuller diagnosis, in English, of the family Sagartiadæ is

practically synchronous with the former. Five British genera are recognized, viz.: Actinoloba, Sagartia, Phellia, Adamsia, and Gregoria. The foreign genus, Discosoma, is also added to this family. The species of Sagartia are treated in the above order. On p. 122 of his monograph (published Sept. 1, 1858), Mr. Gosse remarks: "The species already described appear to me to be divisible into four or five groups . . . The most typical group, and that for which, should the genus be broken up, I would retain the name Sagartia, includes the following species:—*miniata*, *rosea*, *ornata*, *ichthyostoma*, *coccinea*, *venusta*, *nivea* . . . A group rather less typical than this, I consider to be formed by the following species:—*sphyrodeta*, *pallida*, *pura* . . . Should a generic name ever be required for this group, I propose for it that of Thoe: *troglodytes*, *viduata*, and *parasitica* may be associated as a group departing still more widely from the typical form . . . In the event of redistribution, this group might receive the name of Cylista: *bellis* will probably be considered by many as worthy of generic separation . . . It might be called Scyphia. About the same date Mr. Wm. Thompson (**1858**), being struck by the peculiar characters of *S. bellis*, created for it the genus Heliactis. Both Messrs. Gosse and Thompson overlooked the fact that Dr. Oken (**1815**, p. 349) erected the genus Cereus, constituting *C. bellis* as its type. Profs. Milne Edwards (**1857**, p. 269) and Verrill (**1869**, p. 480), and M. Fischer (**1874**, p. 211), appear to be the only authors who have recognized Oken's priority; although the first does not actually allude to Oken. Again, M. Fischer correctly restores Mr. Pennant's (**1776**) specific name, *pedunculatus* (not "*pedoriculatus*," as M. Fischer spells it), instead of the more commonly adopted *bellis* of Ellis and Solander (**1786**).

From the foregoing abstract it will be perfectly evident that Mr. Gosse regarded *S. miniata* as the type species of his genus Sagartia. For the future these two names must remain inseparable.

Mr. Gosse makes the possession of two œsophageal grooves one of the characters of the genus, and they are certainly very commonly present amongst the Sagartidæ. Mr. G. Y. Dixon has, however, very recently shown (**1888**, p. 120) that one œsophageal groove only is as frequently found as two in both *S. miniata* and *S. venusta*. Of this I have also satisfied myself. My friend and pupil, Mr. Francis Dixon, is at present investigating the anatomy of these and allied species, and he has found (**1888**) that only one pair of directive mesenteries are present in those forms in which the single œsophageal groove occurs, and that in adult specimens the number of paired mesenteries does not appear to bear a direct ratio to the number six. In all cases, amongst adults, more than six pairs of perfect mesenteries are present.

I find that in a specimen of *Cereus pedunculatus* (*Sagartia bellis*, Auct.), of which I have a series of sections, there are two œsophageal grooves and two pairs of directives: the first two cycles of mesenteries (*i. e.* twelve pairs) are perfect, and

in addition an irregular number of the other mesenteries may also reach the œsophagus. The same occurs in *Cylista viduata;* but in *Cylista undata* (*Sagartia troglodytes*) no more than twelve pairs of primary mesenteries, including two pairs of directives, join the œsophagus in the single specimen of which I have sections (M. Fischer (**1874**) regards *C. troglodytes* as a variety of *C. viduata*). In *Gephyra dohrnii* the second cycle of mesenteries extends to the greater portion of the œsophagus, if not to its whole length. Here again two œsophageal grooves and two pairs of directive mesenteries are present in the specimens I have investigated.

Prof. Verrill (**1869**, p. 477) accepts Mr. Gosse's group, but regards the "Sagartinæ" as a sub-family of the Actinidæ (see also Verrill, **1864**, p. 21—Proc. Essex Inst., v. 1868, p. 322—*ibid.* VI. 1869), including within it Metridium, Oken (type *M. dianthus*); Cereus, Oken (type *C. bellis* (*pedunculatus*); Calliactis, Verrill, gen. nov. (type *C. decorata*, Drayton sp.); and Sagartia. Concerning this genus Prof. Verrill says (*l. c.* p. 483): "It seems necessary to restrict this genus to the group considered typical by Gosse, with which the rather less typical group, to which he gives the subgeneric name *Thoe*, and some other forms may also be united; Nemactis (type *N. primula*—Drayton, sp.)

Dr. Andres (**1884**, pp. 130–132) includes Actinoloba, Heliactis, Cylista, Adamsia, Aiptasia, Sagartia, and Nemactis in the Sagartidæ, thus excluding the genera Phellia and Gregoria. Nothing can be said about the latter until it has been re-discovered; it was described from a single, possibly immature, specimen. In addition to Nemactis, which Prof. Verril had previously recognized as belonging to this group, Dr. Andres adds Aiptasia (type *A. couchii*—Gosse).

Prof. R. Hertwig (**1882**), in his most valuable Report, says:—"I have followed Gosse as far as possible in fixing the limits of the families, but my great endeavour has been to define more sharply the meaningless characteristics hitherto in use, by bringing more emphatically forward the anatomical characteristics predominantly developed in the separate families, such, for example, as the nature of the septa [mesenteries], and of the circular muscle, the presence of secondary tentacles and acontia (the latter may appropriately replace the cinclides), and the distribution of the reproductive organs. Thus I have characterized the family of the Sagartidæ afresh, as I have laid down as essential that they should possess acontia and a mesodermal circular muscle, and that the six pairs of principal septa [mesenteries] should be distinguished from the rest by being alone perfect, and not bearing reproductive organs. I found these conditions in a whole series of forms belonging to the Sagartiæ; and if other species hitherto placed among them do not agree in these respects, it is impossible that they should remain in one and the same family" (p. 18).

The family Sagartidæ is succinctly defined (p. 70). The presence of acontia

and of but six pairs of perfect and at the same time sterile mesenteries is made of prime importance. The brothers Hertwig first observed these facts in *Adamsia diaphana*, *Metridium dianthus*, and *Calliactis* (*Sagartia*) *parasitica*. The same occurred in five different species of the "Challenger" material, viz. *Sagartia*, sp. (p. 72), *Calliactis polypus* (Forsk.) (p. 74), *Cereus spinosus*, n. sp. (p. 76), *Phellia pectinata*, n. sp. (p. 81), *Bunodes minuta*, n. sp. (p. 84).

Prof. Hertwig evidently had some misgiving in including the genus Bunodes amongst the Sagartidæ. On page 84 *l. c.* he says: "Among the 'Challenger' material I found one true representative of the Sagartidæ, the external appearance of which justified its being placed in the genus Bunodes. I have determined it as *Bunodes minuta*, as I consider it quite possible that the acontia have hitherto been overlooked in the species of the genus Bunodes. If this view be erroneous it would be necessary to erect a new genus for *Bunodes minuta* and *Bunodes coronata*." It has evidently escaped Prof. Hertwig's notice that M. Fischer had already, in 1874, proposed a new genus, Chitonactis, for the reception of *Bunodes coronata*, Gosse. These two species will be referred to later on.

It is unfortunate that Dr. Hertwig has laid down the law so strongly as he has, as he leaves himself no loophole for escape. We have just seen that *Sagartia miniata*, Gosse (**1853**) (perhaps it should more correctly be designated *S. elegans* (Dal.) (Sir J. Dalyell—**1848**, p. 225, pl. xlvii., figs. 9–11), is the type species of the genus, *S. venusta* being a closely allied species. As previously stated, Mr. Francis Dixon's discovery concerning the irregular occurrence of the mesenteries precludes the drawing of a hard-and-fast line, as has been done by Prof. Hertwig. If we follow this anatomist we shall be landed in the difficulty of excluding the genus Sagartia from the family Sagartidæ!

It appears to me that we have not at present sufficient facts to be able to satisfactorily classify many of the Sagartians. By the latter term I include all those Actiniæ which possess acontia. There is, however, a natural group amongst them which, for the present, I will assume has the value of a sub-family, and which I propose to term the "Chondractininæ."

Chondractininæ.—New sub-family of Sagartian Actiniæ, with the lower portion of the column more or less rigid, upper portion (capitulum) usually different in character from the lower (scapus), and capable of being entirely invected; strong mesodermal circular muscle; numerous contractile tentacles; the primary mesenteries, consisting of two pairs of directives and four pairs of ordinary mesenteries, only are perfect and at the same time are sterile; a cuticle is always more or less developed, except upon the capitulum; warts or nodules are generally present; the acontia, which always occur, are rarely emitted, and then by the mouth only.

It will be seen that this definition is almost the equivalent of that of Prof.

Hertwig's family Sagartidæ, but for the reasons given above this family cannot stand. The proposed sub-family is more extensive than the sub-families Phellinæ of Prof. Verrill, or Phellidæ of Dr. Andres. Although Phellia is probably allied to this group of Actiniæ, I have considered it wiser to propose a new name, partly because we have not sufficient anatomical investigation on Phellia, and partly on account of the more extended range which I desire to give to this sub-division, the older terms being subject to misapprehension.

CHONDRACTININÆ.

CHONDRACTINIA,	Lütken,	Type	*C. digitata* (O. F. Müller).
HORMATHIA,	Gosse,	,,	*H. margaritæ*, Gosse.
CHITONACTIS,	Fischer,	,,	*C. coronata* (Gosse).
ACTINAUGE,	Verrill,	,,	*A. richardi* (Marion).
PARAPHELLIA,	n. g.,	,,	*P. expansa*, Haddon.

CHONDRACTINIA, Lütken, 1860.

Chondractininæ with thick mesoglœa which prevents the body from being much contracted; circular muscle very large; capitulum smooth (usually); summit of scapus surmounted by twelve tubercles (coronal tubercles); scapus more or less warty or nodular; cuticle feebly or strongly developed.

The genus Chondractinia was established by Dr. Lütken (**1860**, p. 190), for *Actinia digitata*, Müller, and *A. nodosa*, Fabr., but without any definition. The name appears to have entirely lapsed, and has only twice since been used—in 1875, by Dr. Lütken, and by Canon Norman in the following year in referring to *C. nodosa*. The genus is very close to Hormathia, Gosse, and they may possibly be merged in future.

Mr. Gosse included *A. digitata*, Müller, in the genus Tealia, which latter he had proposed for *Urticina felina* (*A. crassicornis*, Muller). As this was done without a personal knowledge of the species, but merely from the drawings and description of Mr. Joshua Alder, we may assume that he would have acquiesced in their generic distinctness had he then been acquainted with it. Urticina has priority for the generic name of *A. felina*, Linn. It is open to us either to keep Tealia for

A. digitata, or to drop that generic title altogether, and adopt instead the slightly later, Chondractinia of Dr. Lütken, although the latter was never strictly defined. The objection to retaining the name Tealia is, that it has always been more particularly associated with its type species *crassicornis*, but the latter belongs to an entirely different family of the Actiniæ from that in which *A. digitata* can be placed.

RECOGNISED SPECIES OF THE GENUS CHONDRACTINIA.

Chondractinia digitata (O. F. Müller).

North European Seas.

Chondractinia nodosa (Fabricius).

This is not, however, the *Actinauge* (*Urticina*) *nodosa* of Prof. Verrill. Greenland Seas.

Chondractinia digitata (O. F. Müller).

(Plates XXXII., figs. 7–10; XXXIII., figs. 11, 12; XXXV., figs. 5–7.)

Actinia digitata, n. sp., O. F. Müller, .	1776, Zool. dan. prodr., No. 2796.
Actinia digitata, O. F. Müller, . .	1806, Zool. dan., v., p. 16, pl. cxxxiii.
Actinia digitata, Sars, . . .	1851, Nyt. Mag. Naturvid. vi., p. 143.
Cereus digitata, Milne Edwards, . .	1857, Hist. Nat. des Cor., i., p. 272.
Tealia digitata, Gosse, . . .	1858, Ann. Mag. Nat. Hist. (3), i., p. 417; and Actin. Brit., p. 206, pl. vi., fig. 10.
Tealia digitata, Norman, . . .	1868, Shetland Report, Brit. Assoc., p. 318.
Urticina digitata, Verrill, . . .	1873, Amer. Jour. Sci., vi., p. 5.
Chondractinia digitata, Lütken, . .	1860, Vidensk. Meddel. Nat. Foren., p. 188.
Tealia digitata, Andres, . . .	1884, Le Attinie, p. 203.

The above are the most important references to this species. A more complete bibliography is given by Prof. Andres. Since the time when Müller described the species, Messrs. Sars, Alder, Gosse, and Lütken, have alone added to our knowledge of it. Dr. Lütken describes it as being " in general white, sometimes pale flesh-coloured, especially above nearest the origin of the tentacles, which also have a faint reddish colour. It is of a firm, cartilaginous consistency, and can change its form very little. Its tolerably smooth base widely spreads to embrace shells of living Buccinum or Tritonium; rugged transverse eminences appear in rows on the base; the sides are also beset with oblong knobs which are arranged fairly regularly; at its upper portion they are suddenly larger, and again decreasing in

magnitude, they arrange themselves in twelve rows converging to the mouth. Some examples are, moreover, more tuberculated than others, and in some solitary cases can even be seen almost entirely smooth." Dr. Lütken never saw it "fully expanded, as represented in the 'Zoologia Danica,' but either with entirely withdrawn tentacles, or when only little could be seen."

A good figure of this species has long been a desideratum. Owing to the great kindness and liberality of my veteran friend and colleague, Mr. Gosse, in placing all his drawings and sketches of Actiniæ at my disposal, I am enabled to reproduce two of his beautiful drawings (Pl. xxxii., figs. 7 & 8). The drawing was labelled "*Tealia digitata*, from Mr. Stanger's specimen, del. P. H. G., June 11, 1860." Canon A. M. Norman has, with characteristic generosity, given me two specimens of this species which he dredged from the Shetland Seas in 1863. These I have drawn on Pl. xxxiii., figs. 11 & 12. At the same time he forwarded to me the original drawing of the same species by Mr. Joshua Alder; and although the same drawing was copied in Mr. Gosse's 'Actinologia Britannica' (Pl. vi., fig. 10), I have not considered it superfluous to reproduce it once more. On comparing the two reproductions it will be seen that Mr. Gosse's artist has made the tubercles nearly uniform in size, whereas the coronal tubercles should be large and distinct, as Mr. Gosse quotes from Mr. Alder (*l. c.* p. 206). The capitular tubercles have been rendered too prominent in Mr. Alder's drawing. In neither Mr. Gosse's specimen nor in those I have examined are there any tubercles on the capitulum. It would be ungracious to assume an error of observation on the part of such an accurate observer as the late Mr. Alder, so, for the present, I prefer to leave the presence of small tubercles on the capitulum of this species an open question. Lastly, the colour of the figure in Mr. Gosse's plate agrees neither with Mr. Gosse's own description (*l. c.* p. 206) nor with Mr. Alder's drawing.

From Mr. Gosse's drawing it appears that the colour of this species may be pinkish white and the tentacles violet. With the four coloured figures of living specimens of *C. digitata* (Pl. xxxii.) and the two representations of preserved forms (Pl. xxxiii.) there should now be no difficulty in its identification.

I have submitted half of the specimen drawn in fig. 12, Pl. xxxiii., to an anatomical investigation. A vertical section through the animal (Pl. xxxv., fig. 7) shows the great size of the mesoglœal sphincter or circular muscle (*c. m.*). By transverse sections (Pl. xxxv., figs. 5 & 6) we find that the mesoglœa is relatively very thick. This is especially noticeable in the mesenteries, where it is thicker than in any other Actinian with which I am acquainted: the lacunæ, which are shown in fig. 5, from the irregularity of their appearance, appear to be simply due to some imperfection in the method of preparation. The character of the longitudinal or retractor muscles of the mesenteries is very characteristic (fig. 6). The specimen is a male.

Chondractinia nodosa (Fabr.).

(Plates xxxiii., fig. 13; xxxv., fig. 4.)

Actinia nodosa, n. sp., O. Fabricius, .	1780, Fauna Grönlandica, p. 350.
Actinia nodosa, Gmelin, . . .	1788–93, Syst. Nat. (Linn.), xiii., p. 3133.
Actinoloba nodosa, Blainville, . .	1830, Dict. Sci. Nat., lx., p. 288.
Actinoloba nodosa, Blainville, . .	1834, Manuel d'Actin. et de Zooph., p. 322.
Actinia nodosa, Brandt, . . .	1835, Prod. Descript. Animal, p. 10 (also Ann. Sci. Nat. (2) v., 1836).
Metridium (?) *nodosa*, Milne Edwards,	1857, Hist. Nat. des Cor., &c., i., p. 254.
Chondractinia nodosa, Lütken, . .	1860, Vidensk. Meddel. Nat. Foren. Kjöbenhavn, p. 190.
Actinia nodosa, Möbius, . . .	1873, Jahresb. Com. Untersuch. Deutschen Meere in Kiel., p. 246 (abstr. Ann. Mag. Nat. Hist. (4), xiii., 1874, p. 203.
Chondractinia nodosa, Lütken, . .	1875, Arctic Manual and Instructions, p. 186.
Chondractinia nodosa, Norman, . .	1876, Proc. Roy. Soc., xxv., p. 208.
Actinia nodosa, Andres, . . .	1884, Le Attinie, p. 378.

The typical form of *Urticina* or *Actinauge nodosa* of Prof. Verrill and other American authors is not this species; its identity is discussed further on. It is, however, possible that some of the forms identified under this name may really be this species.

Although this species has not yet occurred within the British marine area, I have deemed it advisable to introduce a description of it for the sake of comparison with *C. digitata*. The accompanying figure (Pl. xxxiii., fig. 13) is the only published drawing of it. For the loan of the specimen from which the drawing was made I am indebted to the kindness of Canon A. M. Norman. The specimen was named by Dr. Lütken, and is therefore authentic. It was obtained from the west coast of Greenland, off Disco Island (lat. 69° 31′ N., long. 56° 1′ W.), from 100 fathoms, July 23, 1875, in the "Valorous" expedition.

Description of a single specimen preserved in alcohol:—Form columnar, thicker above, and expanding below to a large basal disk; wall of body very rigid; capitulum smooth, with an imperfect (?), very thin cuticle; scapus beset with very prominent knobs, many of which have a distinct, nipple-like apex; twelve large coronal tubercles mark the junction of the scapus with the capitulum; most of the other knobs have a more or less distinct vertical arrangement; between these are a few irregularly disposed; the knobs decrease in size inferiorly, and the lower portion of the column and the basal disk are devoid of them; the wall of the scapus is transversely wrinkled, and provided with a thick cuticle. The tentacles are set in several rows, and appear longitudinally wrinkled; the circular muscle is

short and thick; the mesoglœa (mesoderm) is very thick and solid. In the preserved specimen the colour of the capitulum is yellowish white, slightly streaked with brown when the cuticle persists; that of the upper portion of the scapus is a deep, rich brown, becoming paler below; the uncovered portion of the knobs is white. Dimensions: total height, 64mm.; diameter of upper portion of column, 33mm.; diameter of lower portion, 24mm.; average expanse of pedal disc, 41 mm.

Since Fabricius, Dr. Lütken (**1860**) is the only author who has alluded to this species from actual knowledge, and he says very little about it; in fact, since the original, imperfect description, the species has never been properly diagnosed.

A vertical, longitudinal section is given on Pl. xxxv., fig. 4; the most noticeable feature is the great length of the œsophagus. The rigidity of the body is due to the well-developed mesoglœa. The circular muscle in the single specimen examined is short and thick, and marked by several concentric lines.

Hormathia, Gosse, 1859.

Chondractininæ with very contractile body wall, pillar-like when extended, smooth or corrugated, not warty, surrounded by a single row of coronal tubercles; capitulum smooth, or with twelve ridges; base expanded; cuticle more or less developed; circular muscle very large; disc slightly concave, scarcely exceeding the column; tentacles moderately long and slender; perfectly retractile.

RECOGNISED SPECIES OF HORMATHIA.

Hormathia margaritæ, Gosse.

North East Scotland, Shetland.

Hormathia pectinata (R. Hertwig).

West Patagonia.

Hormathia andersoni, Haddon.

Mergui Archipelago (Burmah).

With a single exception (F. E. Schulze, **1875**, p. 139), the hitherto unique species of this genus has been unrecognized, since Gosse described it from a single specimen. Although no specimen of the type exists, nor drawing of the contracted animal, and though no anatomical investigations have been made upon it, I have no doubt that the specimen on which the genus was founded belongs to this sub-family.

Mr. Gosse was uncertain as to the exact number of the large, well-defined warts below the margin; he says "about ten in number"; we are justified in assuming there were twelve.

Canon Norman gave me a specimen of a Chondractinian from Shetland, which agrees so closely with Mr. Gosse's description, that I have no hesitation in relegating it to this genus, although Mr. Gosse describes a living and expanded form. I have further ventured to allocate my specimen to the described species. I was for a long time undetermined whether to do so or to make it a new species, associated with Canon Norman's name, as I had no proof of the identity of the two specimens in question; but on carefully considering the question, I could not discover any valid reason for separating them. The Shetlands, also, are not very distant from the Moray Firth.

The Shetland specimen is very similar to an Actinian described by Dr. R. Hertwig as *Phellia pectinata*, n. sp. (**1882**, p. 81, pl. i., fig. 7, etc.), from the channel between Wellington Island and Patagonia, Station 307, 147 faths., and to a form which I have recently described as *H. andersoni* (**1888**, p. 251, pl. xx.), from the Mergui Archipelago, off Burmah.

This genus is certainly very closely allied to Dr. Lütken's genus, Chondractinia, which was introduced the following year. The absence of tubercles on the column and its greater contractility appear to be the main distinctions. I should hardly have considered myself justified in supporting the distinctness of the two genera, had I not been personally acquainted with two species of each genus. Further, the European, Burmese, and Patagonian are so closely allied, though good species, that they naturally go together. If, therefore, the genus Chondractinia is merged with Hormathia, the species mentioned in this communication will group themselves into two series, corresponding to those species which I have ranged within the two genera under discussion.

Hormathia margaritæ (Gosse).

(Plates XXXIII., fig. 12; XXXV., figs. 10–12.)

Hormathia margaritæ, g. et sp. n., Gosse, .	1859, Ann. Mag. Nat. Hist. (3), iii., p. 47.
Hormathia margaritæ, Gosse, . . .	1860, Actinologia Britannica, p. 219, pl. viii., fig. 1.
Hormathia margaritæ, Schulze, . .	1875, Jahresb. Com. Untersuch. Deutschen Meere, Kiel, Exped., 1872, p. 140.
Hormathia margaritæ, Andres, . . .	1884, Le Attinie, p. 364.

Previously-known Localities.—Moray Firth, near Banff; deep water, clasping a living *Fusus antiquus* (P. H. G.); N.E. Scotland, 69 faths. Station No. 79, on *Fusus antiquus* (F. E. S.).

Description of a single preserved specimen.—Body very contractile; base broader than column, somewhat recurved; column transversely rugose, apparently due to contraction; upper portion of contracted body with twelve small elongated "coronal" tubercles or ridges, which extend some distance along the invected capitulum; circular muscle very strong.

Colour.—Yellowish in spirit.

Dimensions.—Average diameter at base 13 mm.; height of fully contracted specimen 6 mm.

Locality.—Shetland, Rev. A. W. Norman.

I have previously stated that I have had doubts whether I should provisionally keep this specimen distinct from the above species. This was simply on account of the absence of any information, first as to the appearance of a contracted *H. margaritæ*, and secondly, as I had no information as to the appearance of the animal when alive. Canon Norman doubtfully labelled it "*Tealia digitata*," and on sending it to me drew my attention to its probably being distinct therefrom. I mention this as it is direct evidence that it probably resembled that species when alive. A comparison of Mr. Gosse's figure of this species (**1860**, pl. viii., fig. 6) and the accompanying figures of *C. digitata* (Pl. xxxii, figs. 9 & 10) will indicate the general resemblance between them, which would doubtless be still further increased were contracted specimens compared.

The mesoglœa of the specimen investigated is not so thick as in that of *Chondractinia digitata.* A comparison of figs. 12 & 6, Pl. xxxv., will show distinctions between these two species. The mesoglœal circular muscle is very strong, and exhibits certain well-marked characters (Pl. xxxv., figs. 10, 11). In a vertical section the muscular masses are arranged in regular tiers, so that the dissepiments between them appear as parallel lines which externally, *i.e.* towards the ectoderm, are looped something like the tracery of a Gothic church window. It is probable that this peculiar disposition of the muscles will prove of great service in the future identification of this species. The specimen was a female.

CHITONACTIS, Fischer, 1874.

Chondractininæ, with thick mesoglœa, permeated by strands of "mesodermal" muscle-fibres; circular muscle very large; capitulum smooth; twelve pointed coronal tubercles; scapus provided, especially in its upper portion, with pointed papillæ more or less regularly disposed, twelve rows being prominent. Cuticle largely developed on the papillæ.

From a personal knowledge of some examples of Gosse's *Bunodes coronata,* which he obtained from the Bay of Biscay, M. Fischer found that the English author had allocated the species to the wrong genus, and therefore he proposed a new genus for it (**1874**, p. 226).

SPECIES OF THE GENUS CHITONACTIS.

Chitonactis coronata (Gosse).

English Channel; Bay of Biscay; South-west of Ireland.

Chitonactis marioni (Haddon).

Off South-west of Ireland, 325 faths.; Bay of Biscay.

Chitonactis spinosa (R. Hertwig).

South Indian Ocean, lat. 53° 55′ S.; long. 108° 35′ E.; 1950 faths.; off Japan, 1875 faths.

Chitonactis minuta (R. Hertwig).

South Indian Ocean, lat. 46° 16′ S.; long. 48° 27′ E.; 1600 faths.

(?) **Chitonactis longicornis** (Verrill).

Off North-east coast of America, 100–325 faths.

Chitonactis coronata (Gosse).

Bunodes coronata, n. sp., Gosse, .	1858, Ann. Nat. Hist. (3), ii., p. 194.
Bunodes coronata, Gosse, . . .	1860, Actin. Brit., p. 202, pl. vii., fig. 4.
Bunodes coronata, Schulze, . .	1875, Jahresb. Com̄. Untersuch. Deutschen Meere, Kiel, Expd., 1872, p. 140.
Chitonactis coronata, Fischer, . .	1874, Nouv. Arch. Mus. d'Hist. Nat. x., p. 226.
Chitonactis coronata, Andres, . .	1884, Le Attinie, p. 124.

Distribution—S. Devon, moderately deep water, 20 faths. (P. H. G.); N. E. of Hasborough Station, 108, 12 faths. (F. E. S); Port of Arcachon, 20–45 faths. (P. F.); South-west of Ireland, 50 faths. (A. C. H.).

Just before sending to press the present Memoir I was entrusted with some Actiniæ, dredged off the south-west coast of Ireland in June, 1888; the Report of the Expedition which dredged these specimens will shortly be published in the Proceedings of the Royal Irish Academy. Having no time at my command, I am reluctantly obliged to postpone an anatomical investigation on these forms. Amongst them were two specimens which, from their general appearance, and their agreement with the accounts given us by Mr. Gosse and M. Fischer, I am confident belong to the above species.

The following is a description of the two preserved and retracted specimens sent to me:—

Base much expanded, clasping the shell of a Fusus inhabited by a hermit-crab; column transversely wrinkled, studded with small conical pointed warts which do not appear to have any definite arrangement, but are more numerous at the upper portion of the contracted body, and are absent, or nearly so, on the expanded base; the coronal tubercles not distinguished from the others by size; the invection of the upper portion of the body is so complete that no distinct orifice is present when fully contracted. The body wall is thin but not flaccid; the mesoglœal circular muscle is well developed. The specimens had in spirits a dirty drab colour. The œsophagus and disc had traces of a scarlet colouration. Average diameter of base about 25 mm.; average height of contracted specimens, 15 mm.

Chitonactis marioni, n. sp.

(Plates XXXI., figs. 1, 2; XXXIII., figs. 7, 8, 9; XXXV., figs. 8, 9.)

Form.—Body columnar when extended; conical when contracted, with expanded base attached to a spine of *Dorocidaris papillata.* The basal disk extends along the spine to about twice the average diameter of the column; the edges of the basal disk fuse on the opposite side of the spine. The column is provided with irregularly-disposed, small, unequal, sharply-pointed tubercles; these are farther apart and smaller towards the base. The general surface of the column is quite smooth. The upper portion of the column, or rather of the scapus, where it passes into the capitulum, is vandyked, each of the triangular spaces whose apex points upwards being provided with a strong tubercle. The capitulum is short, smooth, with twelve ridges corresponding with the apices of the tuberculated triangles just mentioned; when contracted, these ridges and the tubercles give the appearance of an irregular twelve-rayed rosette. Tentacles rather short and thin; probably 48 in number (6 + 6 + 12 + 24). Disc slightly conical; mouth an elongated slit at right angles to the long axis of attachment.

Colour.—Body pale greenish-grey; tubercles of a darker colour; capitulum pink, the vandyked lower margin and the ridges being white; the latter thus dividing the capitulum into twelve pink panels. Tentacles, primary and secondary, pale-pink, irregularly splashed with madder brown; on their oral aspect a few are simply translucent pink; the remainder are longitudinally striped by extremely delicate lines, usually with the proximal portion of the tentacle strongly-coloured

madder brown; tertiary tentacles translucent white. There are white lines between the bases of the tentacles, evidently indicating the mesenteries, disc pinkish, irregularly but finely splashed with madder brown, lips white, œsophagus pale flesh-colour. In the contracted spirit specimen the ground colour of the column has bleached, and the tubercles have a more yellowish tinge.

Dimensions.—Height, when extended, about 30 mm.; diameter of column 16 mm.; extreme length of pedal disc 35 mm.; length of tentacles 10 mm. The measurements of the specimen in spirit are: height 13·5 mm.; narrow diameter of middle of column (*i. e.* at right angles to line of attachment) 18 mm.; length of pedal disk 34 mm.

Locality.—Attached to a spine of *Dorocidaris papillata*, from 325 fathoms off the south-west coast of Ireland, 53 miles W. ½ S. of Dursey Head, fine sand. (A reference to the capture of this specimen will be found in the "Narrative of the Cruise" in the "Second Report on the Marine Fauna of the South-west of Ireland," Proceedings, Royal Irish Academy, vol. i., 3rd ser., p. 35, 1888.)

On my submitting a sketch of this specimen to Professor Marion, he informed me that it was similar to others which had occurred in the "Travailleur" dredgings; at the same time he kindly gave me proof copies of three unpublished plates which were intended to illustrate the final Paper, of which a preliminary account has appeared (**1882**). On one of the plates was figured a form which, according to a pencil memorandum, Professor Marion regarded as a young example of his *Chitonactis richardi.* Fortunately I possess a fair series of young specimens of this species which, as a matter of fact, very closely resemble the adult form. Apart from this, there are a sufficient number of characters which serve to distinguish the two species in question. It affords me great pleasure, therefore, to associate this species with the name of my distinguished French colleague.

In a vertical section it is seen that the circular mesoglœal muscle has a considerable longitudinal extension: the disposition of the muscular strands is shown in Pl. xxxv., fig. 8. The mesoglœa of the body-wall is not thick; that of the mesenteries is thin; it recalls that of Paraphellia. The general character of the retractor muscle of the mesenteries (Pl. xxxv., fig. 9) is somewhat similar to that in Actinauge. It is instructive to compare my figure 8 with those given by Professor Hertwig for *Cereus spinosus* (**1882**) in *l. c.* pl. vi. fig. 1, and pl. viii. fig. 6.

? Chitonactis longicornis.

Urticina longicornis, n. sp., Verrill, . 1882, Am. Journ. Sci., xxiii., p. 222.
Actinauge longicornis, Verrill, . . 1883, Bull. Mus. Comp. Zool., xi., p. 53, pl. v., figs, 1, 2.
Actinauge longicornis, . . . 1885, Rep. U. S. Fish. Com. for 1883, pp. 514, 534, pl. viii., fig. 21.

This form appears to me to belong to the genus Chitonactis.

Prof. R. Hertwig, in his "Report on the Actiniaria," collected by the "Challenger," (**1882**), rediagnoses the genus Cereus of Oken, and modifies that genus as emended by Prof. Verrill (**1869**, p. 480). By so doing he necessarily eliminates the type species (*C. bellis* = *C. pedunculatus*) from the genus. I agree entirely with Prof. Verrill's interpretation of the genus Cereus, and consequently cannot agree with Dr. Hertwig in his "wish to attach more importance in the diagnosis to the papillose nature of the wall, in order to establish a sharp distinction between this genus and Sagartia," (**1882**, p. 76). This is almost accepting the genus as defined and obscured by Prof. Milne Edwards (**1857**, pp. 263–273).

As I cannot admit that the new species described by Dr. Hertwig as *Cereus spinosus* (**1882**, p. 76, pl. i., figs. 3–5, etc) belongs to that genus, another resting-place must be found for it. Prof. Marion informs me by letter, and I perfectly agree with him, that he considers that this species belongs to the genus Chitonactis. I propose therefore to name it *Chitonactis spinosus* (Hertw.), and it has the appearance of being a very typical member of that genus.

Equally characteristic of the genus Chitonactis is the species which Prof. Hertwig has named *Bunodes minuta*, n. sp. (**1882**, p. 84, pl. ii., fig. 12 *a* & *b*). I have already alluded to this species, and need only say that the description of it, as given by my German colleague, entirely corresponds with the position to which I would assign it. The genus Bunodes, as represented by its type species, *B. verrucosa* (Pennant) = *B. gemmacea* (Ellis) certainly requires to be anatomically studied; but I venture to prognosticate that it will not prove to be a member of the Sagartidæ.

Actinauge, Verrill, 1883.

Chondractininæ with very thick mesoglœa; circular muscle very large; capitulum with twelve ridges corresponding with the twelve coronal tubercles; scapus strongly tuberculate, or nodulate; cuticle present, especially on the tubercles; inner three rows of tentacles with a swollen base.

This genus was erected by Professor Verrill for some large forms which he took to be the *Actinia nodosa* of Fabricius. From a personal examination I am satisfied that the latter is quite distinct from Prof. Verrill's Actinian, which in its turn is very closely allied to the *Chitonactis richardi* of Prof. Marion (1882, p. 460). The bulbous base of the inner tentacles and the character of the tubercles and of the capitulum are sufficient to remove these forms from the genus Chitonactis, so we may utilize Prof. Verrill's genus while discarding his species.

Prof. Verrill describes the genus in the following terms :—

"Large Actinians, with the tentacles and upper part of the body capable of involution. Integument of body of two kinds : that of the lower part is firm, thick, and more or less coriaceous or parchment-like, with persistent, solid warts or tubercles, usually in vertical rows, and sometimes partially covered with a thin chitinous epidermal coating ; that of the upper part of the body forms a marginal brighter-coloured band, below the tentacles, where it is soft and lubricous, secreting mucus abundantly, and rising into longitudinal ridges, crests, or oblong tubercles, which run to and unite with the basis of all [some of] the tentacles. The basal disk may be broad and flat, adherent, or it may be bulbous, clasping mud, or it may ensheathe the branches of Gorgoniæ, etc. Tentacles long and large, contractile [those of the inner cycles having a basal bulb] ; lips with large folds and gonidial grooves." (1883, p. 50).

I have quoted Prof. Verrill's diagnosis of the genus in full, but I would modify it by stating that the capitular ridges run to some, not to "all" the tentacles, and by adding a note on the bulbous base of the tentacles, these alterations are placed in brackets in the foregoing description. Lastly, I would speak of them as "Large Chondractininæ, with the tentacles," etc.

Prof. Verrill believed that this genus "is also closely allied to Urticina, Ehr. (Tealia, Gosse), of which the type is *U. crassicornis* [*U. felina*]. But the latter has the integument soft and lubricous over the whole body, and there is no marked specialization of the submarginal zone: the tubercles, when present, are small, not much thickened, and of the nature of true suckers for attaching foreign substances; and when not in use may so contract as to disappear entirely; the submarginal zone is nearly smooth, with a definite upper margin, and there are no vertical ridges running in on the disk to join the bases of the tentacles, as in this genus and in Actinerus."—[Verrill.] It is now certain *Urticina felina* is very different in every respect from any of the known species of Actinauge.

SPECIES OF THE GENUS ACTINAUGE.

Actinauge sp. (?) (*A. nodosa*, Verrill, not of Fabricius).

North-east coasts of America, 86–1098 faths.

Actinauge richardi (Marion).

Bay of Biscay (considerable depths); south-west of Ireland, 50–110 faths.

Actinauge (sp.)?

Urticina nodosa, Verrill (not of Fabricius),	1873, Amer. Journ. of Sci., vi., p. 440.
Urticina nodosa, Verrill, ...	1874, ibid., vii., pp. 413, 500, pl. vii., fig. 7.
Urticina nodosa, Smith and Harger, .	1874, Trans. Connect. Acad., iii., pp. 11, 54.
Urticina nodosa, Verrill, ...	1882, Amer. Jour. Sci., xxiii., pp. 224, 315.
Actinauge nodosa, Verrill, ...	1883, Bull. Mus. Comp. Zool., xi., p. 50, pl. vi., figs. 6–8*a*.
Actinauge nodosa, Verrill, ...	1885, Rep. U. S. Fish Com. for 1883, pp. 415, 534, pl. v., fig. 20.

Abundant off the north-east coasts of America, from 86–1098 faths.

This species has been well described by my American colleague so far as its external appearance is concerned (**1883**). From the description given by Dr. Fabricius of his *Actinia nodosa*, there was nothing to lead Prof. Verrill to suppose that his was other than that species, or at most a variety of it. Thanks, however, to a personal acquaintance with a single specimen of the Greenland species, which was named by Dr. Lütken, I am able to state definitely what it really is (p. 308), and I find that the typical American species is quite distinct. It is, however, quite possible that the very nodular form described by Prof. Verrill as *A. nodosa*, var. *tuberculosa*, is the true "*Actinia*" *nodosa*. The description (**1883**, p. 53, pl. vi., fig 7, and **1885**, pl. v., fig. 20*a*) agrees perfectly well with the specimen I have examined, with the exception that in Prof. Verrill's form, "The upper retractile border [capitulum] has irregular, strong, longitudinal, unequal crests." In the specimen I examined the capitulum is smooth, or at most with fine longitudinal creases, due to contraction. But Prof. Verrill himself says, "This is a remarkable form, perhaps a distinct species."

If my observations are correct, the type species of the genus Actinauge is without a name; for it would be very misleading to retain the specific name of *nodosa*, owing to its history, even though *A. nodosa*, Fabr., is relegated to another genus. We might retain one of the two varietal names of *coronata*, Verr., or *tuberculosa*, Verr., as the specific name of the type. For the following reasons I cannot see my way to so doing. Prof. Verrill overlooked the presence of the tentacular bulbs in the type forms, and we have no information whether they are present in these two varieties. If present, it would form strong evidence in favour of their being varieties of the type species of Actinauge: if absent, they probably belong to different genera. The latter, as I have just mentioned, may possibly be the true *Actinia* (*Chondractinia*) *nodosa*. The former certainly suggests the genus Hormathia (see p. 309), or perhaps a variety of Chondractinia (see p. 305). Prof. Verrill, however, informs us that "Intermediate states between this and the normal form [Actinauge] are not rare, (**1883**, p. 53). As so much doubt exists, I prefer to leave the specific name of this form still an open question; but if distinct, it might be named after the distinguished American zoologist who has so greatly advanced our knowledge of American Marine Zoology.

The American specimens are "usually" white, dull pale-red, flesh-colour, or salmon; . . . sub-marginal zone is bright-red, orange-brown, or chocolate-brown, often in lighter or darker stripes. The tentacles are usually dark-pink, salmon, or orange-brown, varying to dull-red, or chocolate-brown. Disc usually orange, or reddish-brown, or chocolate, with lighter and darker radii, (*l. c.* **1883**, p. 52).

This species occurs abundantly off the North-east coasts of America, from 86–1098 faths., Verrill (**1885**, p. 534). Prof. Verrill (**1883**, p. 52) says, "I have also received two examples from Denmark, through Dr. Chr. Lütken, of the Copenhagen Museum, which, so far as can be seen from the alcoholic specimens, agree perfectly with some of our less nodose varieties. These were sent as *Actinia digitata*, Müller. But the *Actinia* (or *Tealia*) *digitata* of Gosse and several other European writers may be a distinct species."

Owing to the kindness of Canon Norman, I have been able to examine two spirit specimens of the above species. They undoubtedly appear to be quite distinct, specifically, from the British specimens of *A. richardi*, which I have studied; but then, again, there are strong resemblances between the former and the figures on Prof. Marion's unpublished plate. We can only await the decision of Profs. Verrill and Marion as to the identity of their forms.

Actinauge richardi (Marion).

Plates XXXI., fig. 6; XXXIII., fig. 10; XXXIV., figs. 5–7.)

Chitonactis richardi, n. sp., Marion, .	1882, Comptes rendus, xciv., p. 460 (trans. Ann. Mag. Nat. Hist. (5), ix., 1882, p. 335).
Chitonactis richardi, Andres, . .	1884, Le Attinie, p. 130.
(?) *Actinia tuberculata*, n. sp., Cocks, .	1851, Nineteenth Annual Rep. Roy. Cornwall Polytech. Soc., p. 7., pl. ii., fig. 3.
(?) *Tealia* (?) *tuberculata*, Cocks, Gosse,	1860, Actin. Brit., p. 217.

This handsome species was referred to, but not fully described, by Professor Marion (1882). On submitting a coloured sketch of some Irish specimens of Actiniæ to Prof. Marion, he assured me that this was his species, and at the same time he kindly sent me proofs of some unpublished plates of his which entirely confirmed his statement. I would take this opportunity of acknowledging the cordial manner in which this distinguished French zoologist has rendered me assistance by correspondence, and his kindness in sending to me the proofs of his unpublished plates.

Prof. Marion also informed me, by letter, that he had obtained "this species from 70 mètres to 2000 mètres. It is very polymorphic: the tubercles of the column may increase or almost disappear. The same obtains for the cuticular layer. The foot is prehensile, forming an ampulla, or it may seize hold of an Holtenia or an Isis, and develop lobes. The tubercles of the arm even may be somewhat diminished."

DESCRIPTION OF SOME IRISH SPECIMENS.

Form.—Body cylindrical, both when extended and contracted, and preserved in alcohol; general surface of column smooth, studded with rounded warts, which have a tendency to run into longitudinal rows; pedal disc not expanded, even when the animal is attached to a flat surface; usually the pedal disc is bent round ventrally, the edge being constricted so as to form a cup-shaped concavity, which is filled with sand. The pedal disc thus grips the bottom, and forms an efficient sand-anchor. In two cases the base surrounded a small Natica shell. The capitulum is smooth and slimy, and traversed by twelve strong ridges, each of which divaricates above, and is continuous with the base of a tentacle of the

fourth cycle. Tentacles in five cycles, 96 in number (6 + 6 + 12 + 24 + 48). The inner rows are of moderate length, and provided with a well-marked swelling on the abactinal (ventral) aspect of their base. This enlargement is especially prominent on the tentacles of the three inner cycles. The tentacles of the outermost row are short, without basal bulbs; oral disc smooth, flat; mouth usually oval, with tumid lips.

In the contracted specimens the column is distinctly nodular, the nodules being very irregular both as to size and distribution. A general vertical (longitudinal) arrangement can, however, be occasionally discerned. The tubercles are larger in the upper portion of the column, twelve very prominent ones usually occurring at the bases of the capitular ridges. The nodules become much smaller at the proximal end of the column, so that the constricted edge of the basal disc may be described as tesselated.

Colour.—Column dirty-white, tinged with green; tubercles dull-green; capitulum whitish; tentacles white, or flesh-colour, the oral aspect of the two inner rows variously streaked with madder, or chocolate-brown, sometimes almost of a burnt sienna-brown; basal bulbs always white; outermost tentacles not marked with brown; disc white, streaked and splashed with the same shades of brown as the tentacles; lips usually white; œsophagus either deep madder brown or mahogany colour, or whitish, streaked with brown. In one specimen the disc and all the tentacles were of a pure translucent white, the deep reddish-brown colour of the œsophagus showing up in strong contrast through the gaping mouth.

Dimensions.—The following are the measurements of four specimens preserved in alcohol:—23 mm. high × 19 mm. in diameter; 37 × 29; 43 × 28; 45 × 30.

Locality.—50–110 faths. off the south-west coast of Ireland. (*A*) one specimen from 70–80 faths, 5–8 miles W. of Great Skellig; fine muddy sand, anchored in the sand; (*B*) one specimen, attached to shell of a dead Pinna, 100 faths., 35 miles W. $\frac{3}{4}$ S. of Dursey Head, sand; (*C*) six specimens, two surrounding shell of a small dead Natica, the remainder with basal concavity grasping the sand; 100 faths., 43½ miles W. $\frac{3}{4}$ S. of Dursey Head; (*D*) one specimen from 50 faths., off Glandore.

The great development of the mesoglœa is a noticeable feature in *Actinauge richardi.* The retractor muscles of the mesenteries extend throughout nearly their whole width (Pl. XXXIV., figs. 6 & 7). Even those of the quaternary mesenteries are developed (fig. 7, iv.). The circular muscle of the endoderm (figs. 7 & 9, *c. m. en.*) is not conspicuous. The ectoderm is rubbed off in places, but usually on the tubercles it persists, being protected by a thick cuticle (fig. 8, *cu.*). The circular sphincter muscle is well developed: its character in longitudinal section is seen in fig. 9. The bulbous base of the three inner rows of tentacles is due to a local thickening of the mesoglœa.

I have, doubtfully, referred *Actinia tuberculata* (Cocks) to this species. The account in Mr. Gosse's monograph, which extends the original description, certainly supports the conclusion that it may be a variety of *Actinauge richardi.* Through the kindness of Mr. Gosse I have been enabled to examine a life-size drawing made for him by Mr. Cocks ; in this drawing the tubercles are represented as relatively much smaller and more numerous than in the published figure; the latter certainly more closely resembles the appearance of the Irish specimens. Some of the tentacles are said to be "bifurcated." From the drawing just referred to, I am inclined to believe that the bifurcation is a slight misinterpretation of the bulbous base of the tentacles. In our specimens the swelling was, in some cases, so prominent as quite to suggest a bifid tentacle. In addition to this, some of the tentacles in Mr. Cocks' unpublished sketch are very irregular; whether this is due to an abnormal growth of the tentacles, or whether Mr. Cocks has inadvertently drawn torn tentacles, I cannot say; but it may be confidently asserted that these tentacles are not normal.

PARAPHELLIA, gen. nov.

Chondractininæ with thin mesoglœa; circular muscle relatively small; capitulum smooth, no coronal tubercles; scapus smooth or slightly corrugated; cuticle not developed; body encrusted with sand; base large, often very widely extended.

This is a new genus, erected for a single species, which has hitherto only occurred off the south-west of Ireland.

Paraphellia expansa (Haddon).

Mouth of Bantry Bay, South-west of Ireland; 40 faths.

Paraphellia expansa (Haddon).

(Plates XXXII., figs. 1–4; XXXIII., fig. 6; XXXIV., figs. 1–4.)

Chitonactis (?) *expansa*, n. sp., Haddon, . . 1886, Proc. Roy. Irish Acad. (2), IV., Science, p. 616.

Form.—Column, scapus usually very depressed and turban-shaped, but when weakly or dead obtusely conical, corrugated. Base flattened out and much and variably extended in different directions, the edges crenulated by the insertion of the mesenteries, of which there are about 100; when dead the base may be withdrawn beneath the extended scapus; capitulum short, invisible when the

animal is fully open, crenulated by the mesenteries of the three inner cycles of tentacles when the animal is partially closed, and when the animal is retracted it almost completely covers over the tentacles.

Tentacles short, conical, quadricyclic, 48 in number (6 + 6 + 12 + 24).

Disc perfectly flat.

Mouth, with fairly prominent lips, oval or round when open; usually more or less cruciform when closed.

Colour.—Column, base, translucent buff; scapus, pinkish or flesh-coloured; capitulum, translucent pink; the mesenteries of the primary cycle of tentacles are marked by a pair of somewhat triangular deep madder-coloured spots, the three intervening lobes having a pale yellow spot in their centre.

Tentacles pale translucent madder, with a pale brown terminal spot, and lateral rows of similar spots.

Disc, dark sepia, with six pairs of radial cream-coloured lines extending from the bases of primary tentacles to the mouth, and six pairs of similar smaller converging lines, which arising from the bases of the secondary tentacles die away before reaching the mouth. A row of small cream-coloured spots runs down the central line of each of these twelve areas. A pair of short brown lines extends from the base of each of the tertiary tentacles; this is surmounted and prolonged by a row of small cream-coloured spots, which half-way across the disc unite to form a single median row, which terminates near the mouth: in the triangle thus formed by these converging rows of spots is a short central row of similar spots.

Mouth, lips of a fleshy-brown colour; inside of mouth of a deep madder-brown colour.

When obtained the body of one specimen was entirely covered with grains of sand and broken shells (Pl. XXXII., figs. 1–4); the other with fine sand only (Pl. XXXIII., fig. 6).

Dimensions.—Diameter of base, 21–25 mm.; diameter of scapus, 12 mm.; diameter of disc, 7 mm.

Habitat.—Mouth of Bantry Bay; depth, 40 faths.; bottom coarse sand.

Two specimens of this new genus and species were obtained from the same locality. The first was found in 1885, and described the following year (Haddon, **1886**, p. 616); in the latter year the second specimen was dredged; this specimen closely resembled the preceding. I believe they are sufficiently distinct from previously described species to warrant the erection of a new genus to contain them.

The mesoglœa is relatively feebly developed in this genus, as is specially noticeable in the œsophagus and mesenteries (Pl. XXXIV., figs. 1, 2 & 4). That of the body wall is of medium thickness. The longitudinal retractor muscles of the

primary mesenteries are narrow and reniform in section below (fig. 2), but are broader above (fig. 1).

The secondary and tertiary mesenteries alone bear generative organs. The single specimen sectionized was a female; the secondary mesenteries had their ovaries in their lower third (figs. 2 & 3), while those of the tertiary mesenteries occurred on the middle third. The mesenteries of the fourth rank nowhere projected above the endoderm in this specimen.

The circular muscle of the endoderm of the body-wall (fig. 4) is well developed, and, as in other Chondractininæ, separates the mesoglœa of the mesenteries from that of the body-wall.

As stated above (p. 304), I do not think the time has yet arrived when it is possible to satisfactorily classify the majority of Sagartians. I wish, however, to take this opportunity of making a few notes on some British examples of those which do not belong to the sub-family Chondractininæ.

The genus Sagartia, Gosse, *sensu stricto*, must be retained for *S. miniata*, Gosse (? *S. elegans*, Dal.), *S. venusta*, Gosse; *S. nivea*, Gosse; and *S. rosea*, Gosse, as has already been pointed out (p. 302). Doubtless many non-British forms will find a place here; but it must be by their conforming in structure to these type species. The definition of the genus cannot be modified in any important manner.

The form called by Mr. Gosse *Sagartia* (*Scyphia*) *bellis* (Ell. and Sol.) is the type of the genus Cereus (Oken). Its more correct name is *Cereus pedunculatus* (Penn.).

If strict priority be observed, the species commonly known as *Actinoloba dianthus* (Ell.) will have to be called *Metridium senilis* (Linn.).

The genus Cribrina was introduced by Prof. Ehrenberg (**1834**, p. 264) for those Actiniæ, "poris lateralibus instructa," with the following as its species:—1. *C. verrucosa*, E. (= *A. verrucosa*, Lam. = *Hydra verrucosa*, Gaertn.); 2. *C. glandulosa*, E. (= *A. glandulosa*, Otto); 3. *C. coriacea*, E. (= *A. coriacea*, Cuv. = *A. senilis* Linn.); 4. *C. effoeta*, E. (= *A. effoeta*, Bast.; nec *Priapus polypus*, Forsk.); 5. *C. polypus*, H. and E. (= *P. polypus*, Forsk. = *A. priapus*, Gmel. = *A polypus*, Blainv., nec. *A. effoeta*, Rapp.). As a general rule, the first-mentioned species of a new genus is to be taken as its type; but in this case the type is undoubtedly the fifth species, *C. polypus*. It is evident that it was intended to publish the genus with this species as its type in the "Symbolæ physicæ," which was brought out by Herren Ehrenberg and Hemprich; but I can find no trace of this having been done. At all events, Prof. Ehrenberg associates Hemprich's name with his own both for the genus and for this species, but for no other species. Thus the author regarded it as typical. The genus is based upon, and named from, the presence of lateral pores; none of the first three named species are perforated; therefore on this ground alone we are justified in limiting the generic name to its perforated

members. The genus Cribrina then has *C. polypus* (Forsk.) for its type species. I am aware that this species is possibly a synonym for *C. effoeta* (Linn.).

The genus Calliactis, Verrill (**1869**, p. 481), is very closely allied to Cribrina, *s. s.* If they are identical the older name must stand.

It is now admitted by many zoologists that *A. parasitica*, Couch, is *A. effoeta*, Linn.; but Dr. Andres in his monograph (**1884**) makes *A. effoeta*, Linn., and *A. viduata*, Müll., the same species; and he gives *A. parasitica* as a synonym of *A. rondeletii*, D. Ch. Personally, I am inclined to follow M. Fischer (**1874**) and others in regarding *A. parasitica* as a synonym of *A. effoeta*, Linn. (not, however, "*A. effoeta*," as M. Fischer spells it). The correct name of this form is therefore *Cribrina effoeta* (Linn.).

The only anatomical account we have of the genus Phellia consists of two semi-diagrammatic figures of *Phellia limicola*, Andr. (figs. 2 & 3), in the Introduction of Prof. Andres' monograph (**1884**, pp. 73, 74). From these figures it appears that only the six primary pairs of mesenteries are perfect, and at the same time they alone bear the generative organs. Acontia are present. No mesoglœal circular muscle is indicated as being present.

While Phellia may be placed among the Sagartians—by the possession of acontia—we cannot regard it as belonging to the Chondractininæ.

Sagartia, sp.

Figures of a Sagartian are given on Pls. XXXII., fig. 6.; XXXIII., fig. 5, which I have not time to properly describe or identify, and I prefer to leave them unnamed to hazarding an untrustworthy determination. It was found attached to a Caryophyllia at a depth of 16 faths., 42 miles off the Great Skellig, south-west of Ireland, in 1886.

Base expanded, attached to side of a large Caryophyllia (Haddon, **1888**, p. 36); scapus translucent pink, with attached grains of sand; capitulum elongated, translucent white; opaque white spots at base of tentacles; tentacles short, swollen, conical, pinkish, with madder ring near their base; disc pinkish; lips madder.

Gephyra dohrnii, Von Koch.

(Plates XXXI., figs. 3–5 ; XXXIII., figs. 3, 4.)

Gephyra dohrnii, g. and sp. nn., Von Koch,	1878, Morph. Jahrb. IV., Suppl., p. 78, pl. v.
Gephyra dohrnii, Andres, ...	1880, Mitth. Zool. Stat. Neapel., ii., p. 314.
Gephyra dohrnii, Marion, ...	1882, Comptes rendus, xciv., p. 458 (transl. in Ann. Mag. Nat. Hist. (5), ix., 1882, p. 334).
Gephyra dohrnii, Hertwig, ...	1882, "Challenger" Rep. Actiniaria, vol. VI., pt. xv., p. 86.
Sagartia dohrnii, Andres, ...	1884, Le Attinie, p. 166.
Sagartia dohrnii, Carus, ...	1884, Prod. Faunæ Medit., i., p. 70.
Gephyra dohrnii, Haddon, ...	1886, Proc. Roy. Irish Acad. (2), iv., Sci., p. 616.

Distribution.—Mediterranean, Bay of Biscay, South and South-west of Ireland.

DESCRIPTION OF IRISH SPECIMENS.

A. Column smooth; base large and thick, more or less surrounding the stems of a Tubularian, to which it is attached, sometimes completely enwrapping them, the two edges of the basal disc fusing to form a short open tube; no horny or cuticular deposit was noticed. The disc and tentacles can be completely retracted; in that condition the column is conical in form.

Tentacles short, conical, but rather slender, tricyclic, 12 + 12 + 24; the tentacles of the first two cycles are about of equal length; those of the outer row are shorter than the others.

Disc raised, produced in the centre into a turban or even trumpet-shaped oral protuberance; mouth more or less circular.

Colour.—Column pale, pinkish orange, often more pink, especially the ventral surface of the disc; tentacles, primaries slightly darker than the disc; tertiaries lighter, translucent, without any markings.

Disc translucent pale orange, with 24 pale radiating lines, indicating the mesenteries; oral portion of disc with 12 dark orange lines, which are inclined to be thicker towards the periphery. This portion of the disc is separated from the remainder by a white circle; throat deep orange. The twelve primary tentacles have an almost complete deep orange ring at their base.

Locality.—About 30 miles off the Fastnet, south-west of Ireland, 80 faths.; and 9 miles south of Glandore, 40 faths.

B. These specimens were taken on another occasion, and the following notes were taken:—Body translucent orange or flesh colour; disc translucent, white

ring round mouth; the insertions of the mesenteries appear as double white radial lines; œsophagus pinkish orange or flesh colour; tentacles translucent flesh colour, with darker line round the base and at the tip; mouth at right angles to long axis of attachment. Tentacles, apparently, 12 + 12 + 24.

Locality.—5–8 miles west of Great Skellig; south-west of Ireland, 70–80 faths.

C. At the same time the following Actiniæ were obtained, which I take to be a variety of the same species (pls. xxxi., fig. 3; xxxiii., figs. 3 & 4). Colour, uniform bright cherry; disc and base expanded; scapus constricted; mouth nearly circular; diameter of disc 14 mm. The base secretes a cuticular secretion. Formula of tentacles, 12 + 12 + 24 + 48 = 96.

Same locality as preceding; attached to stems of Tubularia, &c.

On submitting coloured sketches of these specimens to Prof. Marion, he informed me that "your *Gephyra dohrnii* is identical with the Mediterranean forms." Its range is now extended from the Mediterranean to British waters. So far as they have gone, my investigation on the anatomy of this form, on specimens both from the south-west of Ireland and the Bay of Naples, proves that it belongs to the series of typical Sagartians; but I cannot regard it as belonging to the genus Sagartia, as above restricted.

I venture to call Prof. Verrill's attention to the need of re-examining his *Sagartia spongicola* (**1883**, p. 47, pl. vi., fig. 3; and **1885**, p. 534, pl. vii., fig. 200). It has very close resemblance to this species.

Fam. EDWARDSIDÆ, Andres (1880).

Elongated Actiniæ with a vesicular base; eight mesenteries only present, including two pairs of directive mesenteries; the remaining four mesenteries are unpaired; all the mesenteries bear reproductive organs; tentacles simple, usually more numerous than the chambers of the cœlenteron.

Sole genus.—EDWARDSIA, Quatrefages (1842).

Column long, cylindrical, divided into capitulum, scapus, and physa; the capitulum and physa are retractile, the scapus usually invested with a friable cuticle; tentacles variable in number, from 16–32 in the adult condition (occasionally 8 in number?)

The number and disposition of the mesenteries are alone sufficient to render

the genus Edwardsia well defined, and, in the present state of our knowledge, sufficiently so to warrant it standing as the sole genus in the family of the Edwardsidæ.

Prof. Andres (**1883**) subdivides the Edwardsidæ into two genera—Edwardsia, provided with 16 tentacles; and Edwardsiella, with more than 16 tentacles. Other characters are mentioned, none of which, however, appear to be of much value. As the number and arrangement of the tentacles in the Edwardsidæ are so irregular, I prefer, with my friend Mr. G. Y. Dixon (**1886**), to relegate all the species to the one genus.

BRITISH SPECIES OF EDWARDSIA.

EDWARDSIA	BEAUTEMPSII, Quatrefages.	EDWARDSIA	ALLMANI, M'Intosh.
,,	CARNEA, Gosse.	,,	GOODSIRI, M'Intosh.
,,	TIMIDA, Quatrefages.	,,	TECTA, n. sp.

(?) E. CLAPARÈDII, Pancer sp.

Edwardsia beautempsii, Quatrefages.

(Plates XXXIII., fig. 17; XXXVI., fig. 4.)

Edwardsia beautempsii, n. sp., Quatrefages, 1842, Ann. des Sci. Nat. (2), xviii., p. 69, pl. i., fig. 1.
Scolanthus callimorpha, n. sp., Gosse, . 1853, Ann. Nat. Hist. (2), xii., p. 157, pl. x.
Edwardsia callimorpha, Gosse, . . . 1860, Actin. Brit., p. 255, pl. vii., fig. 7.
Edwardsia beautempsii, Andres, . . . 1884, Le Attinie, p. 92.
Edwardsia beautempsii, Pennington, . . 1885, Brit. Zooph., p. 177.

(For full bibliography consult Andres.)

Dr. A. Andres was the first to connect Mr. Gosse's species with that of M. de Quatrefages; in this as in other matters he has been followed by Mr. Pennington. I have very carefully compared the published accounts, and with the further advantage of being acquainted with the animal itself, and of having access to a coloured drawing of Mr. Gosse, I have come to the opinion that the forms are identical, and consequently Mr. Gosse's name must give place to that of M. de Quatrefages. As a matter of fact, the Irish specimen is intermediate, so far as colour and markings are concerned, between the types described by these authors, and thus demonstrates their identity.

The following is a description of the single specimen we obtained :—

Form.—As in Mr. Gosse's description, the physa is short and rounded; at certain times it *appears* as if the apex was perforated.

Colour.—Scapus, tawny orange; cuticle friable, darker than the scapus; physa transparent, with a very slight pinkish tint; capitulum pinkish, closely speckled with minute white spots, and œsophagus shines through, of a madder colour; madder-brown ring below the base of the tentacles interrupted by 16 short white lines, 8 of which correspond with the insertion of the mesenteries, and the other 8 are intermediate. Tentacles translucent, with numerous opaque, yellowish-white irregular spots and ring-like marks, and a smaller number of dark rings; tips pinkish. Disc, pale, flesh-colour, finely spotted with madder; circum oral chevron ring, also madder-coloured; a pair of dark madder spots about half way up each of the radii of the primary tentacles. Mouth linear, pale colour, on a small cone.

Dimensions.—Length, when extended, 48 mm.; average diameter, 3 mm.; expanse of tentacular crown, 17 mm.

Locality.—Berehaven; Bantry Bay, 10 faths., July, 16, 1886.

[Previous localities:—Weymouth; Brixham; Guernsey (Gosse). Is. Chansey, Manche (Quatrefages), St. Malo, Roscoff (Grube)].

Edwardsia carnea, Gosse.

(Plates XXXIII., fig. 15; XXXVI., figs. 5 & 6.)

Edwardsia carnea, n. sp., Gosse. . .	1856, Ann. Mag. Nat. Hist. (2), xviii., p. 219, pl. ix., figs. 1–4.
Edwardsia carnea, Gosse, ...	1858, *Ibid* (3), i., p. 418.
Edwardsia carnea, Gosse, ...	1860, Actin. Brit., p. 259, pl. vii., figs. 5, 6; pl. xii., fig. 3.
Edwardsia carnea, Hincks, . . .	1861, Ann. Mag. Nat. Hist. (3), viii., p. 363.
Edwardsiella carnea, Andres, . . .	1884, Le Attinie, p, 94.
Edwardsiella carnea, Pennington, . .	1885, Brit. Zooph., p. 178.

Localities.—Torquay, South Devon; Tenby, South Wales (Gosse).

I am indebted to Mr. G. Y. Dixon for permission to publish the following memorandum on this species:—

"*April* 24, 1887.—I have been studying the *Edwardsia carnea* that I got at Babbacombe last week, and have come to the conclusion that it may most easily be distinguished from *E. timida* by ridges that may be seen on its capitulum. I have been able to observe them best when the animal is in the act of protruding its disc and tentacles. Then if you look vertically down on the animal, viewing it with a side light, you will see that each of the eight broad regions which make up the capitulum is raised into a ridge running down its median line parallel to

the direction of the region itself. As the animal expands these ridges disappear, but they re-appear when it withdraws its disc and tentacles down into the capitulum. The shape of the capitulum, too, in *E. carnea*, is more barrel-shaped than in *E. timida;* the opposite sides of the capitulum in *E. timida* are always parallel, while those of *E. carnea* are swollen like the sides of a cask."

Mr. Dixon obtained a couple of specimens from Mr. Gosse's own locality at Petit Tor, near Torquay, and kindly gave me one, on which I have made a few anatomical notes (*vide* p. 331).

Edwardsia timida, Quatrefages.

(Plate XXXVI., fig. 3).

Edwardsia timida, n. sp., Quatrefages, .	1842, Ann. des Sci. Nat. (2), xviii., p. 70, pl. ii., fig. 1.
Edwardsia harassi, n. sp., Quatrefages, .	1842, *Ibid*, p. 71, pl. ii., fig. 2.
Edwardsiella harassi, Andres, . . .	1884, Le Attinie, p. 94.
Edwardsiella timida, Andres, . . .	1884, *Ibid*, p. 96.
Edwardsia timida, G. Y. Dixon, . .	1886, Proc. Roy. Dub. Soc. (N.S.), v., p. 100, pl. vi.

Prof. H. Milne Edwards (**1857**, p. 286), and M. Fischer (**1875**, p. 203), merely repeat M. de Quatrefage's description of these two species. Mr. G. Y. Dixon found an Edwardsia near Dublin, which he describes very carefully and fully, after an examination of eight specimens: these he regards as examples of *E. timida*, and at the same time he unites M. de Quatrefage's two species, in which I also agree with him. I may add that I have several times examined his specimens when alive, and am able to corroborate his statements and support his conclusions.

Localities.—Is. Chansey, Manche (Quatrefages); Malahide, Co. Dublin (Dixon).

Edwardsia tecta, n. sp.

(Plates XXXIII., fig. 16; XXXVI., figs. 1 & 2).

Form.—Column elongated, thin; divided into physa, scapus, and capitulum; physa small, delicate, completely retractile within the scapus; no terminal pore can be detected in sections made through the apex of the physa; scapus smooth, with eight shallow longitudinal grooves, and without tubercles. The investment is thin, wrinkled, translucent, and in preserved specimens quite loose, forming a "membranous" tube within which the animal is withdrawn. Capitulum delicate,

completely rectractile; tentacles eight in number, in the single specimen examined.

Colour.—No accurate notes were taken of the living animal. The colouring was certainly inconspicuous; my belief is it was of a dirty-white colour, with the disc and tentacles variegated with pale brown. Colour in preserved specimens dirty yellowish-grey

Dimensions.—Contracted specimen 12 mm. long; 2 mm. diameter.

Locality.—Nymph Bank, 52 faths., 28 miles south-west of Ballycotton, Co. Cork; and 70–80 faths., 5–8 miles west of the Great Skellig, off Co. Kerry.

Two specimens of this inconspicuous Edwardsia were examined; it is certainly distinct from any other British example of the genus, and, so far as I can gather from the published accounts, equally distinguishable from other described forms.

The ectoderm of the retractable portion of the anterior extremity of the column, the capitulum, and of the tentacles, consists of a layer of tall, ciliated, columnar cells, with distinct nuclei; the bases of those of the latter form a slightly pleated sheath of longitudinal muscle fibres. Nematocysts are also present in the ectoderm of the tentacles. The ectoderm of the scapus consists of shorter cells than the foregoing, and their nuclei are more rounded; they too are ciliated. The cells are very granular, but their basal portion is clear, and contains numerous deeply staining nuclei, which are much smaller than the nuclei of the epithelial cells. They appear, however, only to occur in the extreme anterior region of the scapus. Similar nuclei occur also in the ectoderm of the œsophagus and in the mesenterial filaments.

In the lower portion of the scapus the cells change somewhat in character; large round nuclei, which are also found higher up, are more abundant: they probably belong to the cells which secrete the investment. The ectoderm cells of the œsophagus are very narrow; those lining the œsophageal groove are shorter and possess very long cilia; the œsophageal ectoderm is ciliated, possesses numerous nematocysts and glandular cells; deeply staining nuclei are extremely abundant.

The endoderm does not call for special attention; scattered about are deeply staining masses, which are possibly glandular. The mesenterial filaments contain gland cells in their upper portion only; nematocysts occur as usual.

The mesoglœa is very clear; in the body-wall it often contains foreign bodies, which have become included by pressure from without.

The folds of the longitudinal retractor muscles of the mesenteries have a remarkably leaf- or moss-like appearance. The folds are about ten in number, either not at all or but very slightly forked, with the exception of the proximal fold, which is large and branched in a manner which recalls a deer's antler. The small proximal longitudinal muscle of the mesentery has a few moderately long folds at right angles to its length, and which may be slightly bifurcated.

In addition to the external differential characters which have already been enumerated, it is possible to distinguish the various species of Edwardsia by anatomical methods—at least such is the case for all the species I have been able to examine. Unfortunately, as most of my material has not been sufficiently well preserved, I am unable to give as precise an account as I should wish.

At present I can only speak definitely for the longitudinal retractor muscle of the mesentery, and more especially for the small longitudinal muscle which is present at the proximal extremities of the mesenteries. As the folds of this endodermic muscle occur on each side of supporting lamina of the mesentery they give a tree-like appearance to the muscle. I will refer to it as the parietal muscle.

In *Edwardsia tecta* (Pl. xxxvi., fig. 2) the folds of the parietal muscle are about half-a-dozen in number on each side, rather thick, of moderate length, and several are more or less divided.

In *E. beautempsii* (Pl. xxxvi., fig. 4) the folds of the parietal muscle number about a dozen on each side; they are relatively longer, and much more slender than in the former species, and exhibit very little tendency to divide. There are remarkable spaces in the mesoglœa of the body-wall, apparently filled with some non-staining, coaguable fluid. These spaces open to the ectoderm by raised conical orifices; the ectoderm is also raised up over them, but I cannot find any opening to the exterior. The pockets do not appear to be invaginations of the ectoderm, as I cannot distinguish any epithelial lining; the neck of the crater seems to be plugged by ectodermal cells, the peripheral cuticle of which is entire. They occur in the intervals between the mesenteries at the posterior end of the column. We must await other and better preserved material before coming to a conclusion as to their nature.

In *E. carnea* (Pl. xxxvi., figs. 5, 6) there are some half-a-dozen short thick folds of the parietal muscle rarely, and then but slightly bifurcate. The longitudinal retractor muscle consists of a few (eight to ten or so) slightly branched folds. The only specimen at my command cut very badly; so I am unable to give further histological details.

In *E. timida* the parietal muscle bears some resemblance to that of *E. beautempsii*, but it is relatively smaller, and the mesoglœa of the proximal portion of the mesentery is thinner; in the latter species there is a lateral thickening and extension of the mesoglœa, which gives a characteristic arrow-head appearance to it in transverse section. In the present species the lateral folds are about ten in number, and may be slightly divided; the proximal fold is usually complicated. The rectractor muscle of the mesentery is very large and pear-shaped in section; the character of the folds can best be understood by a reference to the figure (Pl. xxxvi., fig. 3). The specimen examined was a male.

OTHER DESCRIBED BRITISH EDWARDSIA :—

Edwardsia allmani, n. sp., M'Intosh,	. 1865, Proc. Roy. Soc. Edinb., p. 394; Marine Invert. Fauna, St. Andrews, p. 37, pl. ii., fig. 3; pl. vii., figs. 1–4.
Edwardsia goodsiri, n. sp., M'Intosh,	. 1865, *l. c.*, p. 395; *l. c.*, p. 38, pl. ii., fig. 4; pl. vii., figs. 5–7.

Locality for both of above, Saint Andrews.

On p. 262 of the "Actinologia," Mr. Gosse records the capture of an Edwardsia by Canon Kingsley at Torquay, which he (Gosse) thinks is referrible to *E. beautempsii*, Quatref. I have already stated my belief that *E. callimorpha*, Gosse, is that species. What then is this other form? The following is all the description we have of it. While generally agreeing with *E. callimorpha* in size and form, it differed in the following points:—1. The scapus was less opaque, more smooth and lubricous, and studded with longitudinal rows of minute warts between the invections. 2. The capitulum was clavate, proportionately longer, and of the same colour as the scapus, a pale pinkish-buff, or light orange. 3. The tentacles were fourteen in number, slightly uncinate or incurved, banded with dark buff. 4. The disc was transparent and colourless, with a dark protruded mouth.

In the above particulars this Edwardsia agrees so well with the description and beautiful figures of *E. claparedii* (Panc.) given by Professor Andres ("Le Attinie," p. 90; pl. xi., pp. 1-5), that we may with justice, for the present, allocate it to that species.

The following immature forms of British Edwardsia have been described:— *E. microps*, Andres (Gosse), S. Devon (*c. f.* Gosse, "Actinologia," p. 252, and Andres, "Le Attinie," p. 97); and *E. sp. incert.*, Dublin Bay (A. C. Haddon, **1886**, p. 527).

HALCAMPIDÆ (not of Andres).

Elongated Actiniæ, with a vesicular base; six pairs of perfect mesenteries present, including two pairs of directives; small imperfect mesenteries may be absent or present in all or in some of the exocœles; reproductive organs present on all the mesenteries, or absent only on the sulcular directive mesenteries; tentacles simple, usually twelve in number, but may be twenty or twenty-four; one or two œsophageal (gonidial) grooves present or absent.

Mr. Gosse (**1860**, p. 227) erected the family Ilyanthidæ to include Ilyanthus, Peachia, Halcampa, Edwardsia, Arachnactis, Cerianthus, and Saccanthus. Prof. Verrill (**1864**, p. 26) excluded the Cerianthidæ. Profs. Allman (**1872**, p. 394),

O. and R. Hertwig (**1879**, p. 124), and Andres (**1880** A, p. 123) further detached Edwardsia. Prof. R. Hertwig (**1882**, p. 92) still includes Ilyanthus, Peachia, and Halcampa in the family, but Prof. Andres (**1884**, p. 240) confines the Ilyanthidæ to the genus Ilyanthus, the other two genera being types respectively of the Siphonactinidæ and Halcampidæ.

I have framed the above definition so as to include Peachia as well as Halcampa and Halcampella, for they appear in many respects to be allied genera; but Peachia may prove to be sufficiently distinct to necessitate a family of its own. Till we have an account of the anatomy of Ilyanthus, it hardly appears wise to associate it with the other forms.

Halcampa is the type genus of the family Halcampidæ. Halcampella (Andres, **1883**, p. 103) appears to differ solely in the fact that there are twenty-four tentacles. Three species of Halcampa (*H. albida*, Ag., *H. producta*, Stimps., *H. capensis*, Verr.) have been described as possessing twenty tentacles; the two former (if they are distinct) have twenty longitudinal sulcations, evidently corresponding to the insertion of the mesenteries. The more typical species of Halcampa may have only six pairs of perfect mesenteries (*H. clavus* of R. Hertwig), or there may be six pairs of imperfect mesenteries, one pair in each exocœle, as in the British species. In Peachia, however (*vide* page 338), there are twenty mesenteries, six pairs of perfect mesenteries, and four pairs of imperfect mesenteries; but in this genus there are only twelve tentacles. Possibly the three species first mentioned may prove to belong to a genus intermediate between Halcampella and Peachia. The other recorded apparent anomaly in the number of tentacles has already been referred to (p. 332); for *H. microps* (Gosse) is almost certainly an immature Edwardsia.

BRITISH GENERA OF THE FAMILY HALCAMPIDÆ.

HALCAMPA, Gosse. PEACHIA, Gosse.

HALCAMPA, Gosse, 1858.

Halcampidæ, with elongated vermiform body, divisible into capitulum, scapus, and physa; the capitulum is retractile; no sharply-defined circular muscle; œsophageal grooves present or absent; tentacles twelve in number (? twenty in some species); physa perforated by about twenty-four apertures at its apex; six pairs of imperfect mesenteries present or absent (? four pairs in some species).

The adult Halcampa is a truly hexamerous Actinian; but Dr. R. Hertwig, in describing a form he identified as *Halcampa clavus* (Quoy and Gaimard) (**1882**,

p. 92), says it "is so clearly an intermediate form that I was for long dubious whether I should treat of it under the Edwardsiæ or Hexactiniæ." The reason for this statement is found on p. 95, where he states: "As I was preparing a series of sections through the one half of the physa of the larger specimen, it struck me that three septa [mesenteries] (including the pair of directive septa) were not so strong as the other septa, inasmuch as their longitudinal muscular cords became sooner indistinct (pl. xiii., fig. 7). In the second smaller Halcampa, in which I was able to make sections through the entire body, four septa were somewhat smaller than the eight others." Prof. Hertwig then alludes to *Halcampa fultoni*, but reverses Dr. Strethill Wright's account. The latter said, "Eight septa were continued downwards to the lower extremity of the body, and had their free edges bordered by a convoluted ciliated band, furnished with cnidæ, or thread cells; the intersepta (*i.e.* the four smaller mesenteries) bore no convoluted bands (Ann. Mag. Nat. Hist. (3), viii., 1861, p. 132). Dr. Hertwig goes on to say: "All this shows that an unequal development of the septa, and consequently a difference in their morphological value, is not unusual in Halcampa. If we assume that the eight stronger septa are homologous with the septa of Edwardsia, whilst the four other septa are new formations, then the genus Halcampa would present us with transition forms between the Edwardsia and the Hexactiniæ" (*l. c.*, p. 95).

I have recently demonstrated (**1887**, p. 473) that the eight stronger mesenteries of the parastic larva, in *Halcampa chrysanthellum* are homologous with the eight mesenteries of Edwardsia, and that not only in this respect, but also in the presence of only eight tentacles, the larval Halcampa approaches the Edwardsiæ. There can be no doubt that Dr. Strethill Wright examined an older larva of *H. chrysanthellum* than I obtained, as his specimen had twelve tentacles. On referring to the rough diagram given in the paper quoted above, I find that his four "intersepta" correspond with the four weak mesenteries which I have figured (*l. c.*, **1887**, pl. xi., figs 6-8). It is unfortunate that Prof. R. Hertwig gives us no information as to which of the mesenteries are stronger or weaker in his smaller specimen; probably they correspond to the sulcar elements of the lateral pairs. His account of the mesenteries of the larger specimen does not inform us as to which of the mesenteries are imperfect in addition to the pair of directives, the only clue we have is his fig. 7, pl. xiii. The section includes a single large mesentery on one side of the small directives, on the other side are two large mesenteries with a small one between them. From their behaviour in the British species of Halcampa, it is fair to assume that these are the sulcular directive mesenteries: the other weak mesentery would correspond with the sulcar member of the sulculo-lateral pair. If the remaining half followed the usual arrangement in the genus, the mesenteries in this species would resemble in the main those of the lower portion of the body of *H. chrysanthellum.*

BRITISH SPECIES OF HALCAMPA.

HALCAMPA CHRYSANTHELLUM (Peach).
,, ARENAREA, Haddon.
,, CLAVUS, Hertwig.

Halcampa chrysanthellum (Peach).

(Plates XXXV., figs. 1 and 2; XXXVI., fig. 7.)

Having a short time ago (**1886**, p. 1) critically discussed this species, there is no need to repeat the bibliography there given. I find, however, that two synonyms have been omitted from the bibliography (*l. c.* page 2): *Actinia chrysanthellum* should be inserted opposite to "Cocks, 1851," and *Halcampa chrysanthellum* opposite to "Gosse, 1860." The ,, ,, marks which follow will then be correct. I have recently found that Prof. K. Möbius, in 1873, records *Edwardsia chrysanthellum*, from Kiel, 7-10 faths., mud; and from Bülk (near Kiel) 10½ faths., grey sandy mud and algæ: he now regards this as the correct specific name for *E. duodecimcirrata*, Sars, and of Meyer and Möbius.

From a note taken at the time this species appears to occur at Nymph Bank, Co. Cork, 52½ fathoms, but I cannot now find the specimen, so there may be some mistake in the identification; at all events the parasitic larval form was collected by the tow net in Ballycotton Bay, Co. Cork, the previous night. Having recently (**1887**, pp. 473-481; pl. xi.) given an account of the parasitic larva of this species, nothing more need here be said.

Halcampa arenarea, Haddon.

(Plates XXXII. fig. 5; XXXIII., fig. 14; XXXV., fig. 3; XXXVI., figs. 8–10.

Halcampa arenarea, n. sp., Haddon, . . 1886, Proc. Roy. Irish. Acad. (2), iv., Sci., p. 616. (The specific name was erroneously printed "*arenacea.*")

Form.—Column divided into capitulum, scapus, and physa; physa smaller, globular, apparently without suckers, completely retractile; scapus cylindrical, even when extended, very contractile, provided with numerous long permanent suckers, which adhere to grains of sand; capitulum cylindrical when fully extended, completely retractile. Tentacles—twelve, marginal, monocyclic, cylin-

drical, obtuse, about as long as diameter of disc, usually so carried that the endocœlic tentacles point forwards, the exocœlic being recurved.

Disc.—Flat; mouth linear.

Colour.—Physa transparent, almost colourless; scapus a dull, pale, madder brown; capitulum translucent, dirty, flesh-colour: tentacles of same colour as the capitulum, with four imperfect very pale-brown marks, and an M-shaped mark, at the base of which the vertical limbs are situated on the sides of the tentacles; disc of same pale flesh-colour; the twelve mesenteries appear as pale radiating lines; at the base of each tentacle is a pair of narrow, wedge-shaped, pale-brown marks, the apices of which point towards the mouth; between these and the mouth is a lenticular pale-brown spot, which, with its fellows, form a ring round the mouth, and separated from it by a short interval. Mouth brownish.

In another specimen the markings of the disc and tentacles were much less distinct than in the former specimen; the axial line of the disc and the axial tentacles were decidedly bleached, and the capitulum was translucent white, with white bands.

Dimensions.—Length about 35 mm.; in the ordinary condition it can contract to about 18 mm.; diameter variable, average about 7 mm.

Habitat.—South-west of Ireland, sand; mouth of Kenmare River, 38–44 faths. (1885); mouth of Bantry Bay, 38 faths. (1886).

Halcampa clavus, R. Hertwig.

There is a record of a third British species of Halcampa which requires further elucidation. On p. 674 of Capt. Tizard and Dr. J. Murray's paper on the "Exploration of the Faroe Channel, during the summer of 1880, in H. M. S. (hired ship) 'Knight Errant,'" (Proc. Roy. Soc. Edinburgh, Session 1881–82, vol. xi.), *Halcampa clavas* is recorded from sounding 17, Station 2, lat. 60° 29′ N., long. 8° 19′ E., July 28, 375 faths., bottom temperature, 31°·0; that is, from the northern (cold area) declivity of Wyville Thomson Ridge in Faroe Channel. Dr. Murray informs me by letter that this specimen was identified by Dr. R. Hertwig. In his "Challenger" Report, p. 92, Prof. Hertwig describes as *Halcampa clavus* an Actinian dredged at Kerguelen (25-120 faths.) It is difficult to understand why Dr. Hertwig did not adopt *H. purpurea*, Studer (**1878**, p. 545), as the name of this species. Dr. Studer's specimens were obtained from the same locality as those dredged by the "Challenger." This may or may not be identical with the *Actinia clavus* of Quoy and Gaimard, which the French naturalists found attached to a Medusa in Bass' Straits; but it appears to be extremely improbable that an antarctic species of Halcampa should reappear in the cold area of the Faroe Channel, I can only

conclude that Prof. Hertwig was struck by a superficial resemblance, and named the specimen before he had made any anatomical investigation of it.

As Dr. Andres points out (**1884**, p. 97), *Halcampa microps*, Gosse (*cf.* "Actinologia," p. 252), is an immature Edwardsia, and he renames it *E. microps*.

A comparison of the figures on Plates XXXV. and XXXVI. will at once demonstrate that it is perfectly easy to distinguish between the two British species of Halcampa from transverse sections alone. The following are the most obvious differences:—

1. The œsophagus in section is relatively to the diameter of the body very much larger in *H. chrysanthellum* than it is in *H. arenarea* (Pl. XXXV., figs. 1 & 3).

2. The marked difference in the pattern of the folds of the muscular epithelium in the longitudinal muscles of the mesenteries. In *H. chrysanthellum* the folds average ten or eleven in number, and are more open in character than in *H. arenarea:* in the latter species there are usually some fifteen or so.

3. In *H. chrysanthellum* only six mesenteries bear generative products, these being the pair of sulcar directives, and the two sulcular mesenteries of the perfect lateral pairs; the sulcular directives and the sulcar mesenteries of the perfect lateral pairs being sterile (Pl. XXXV., fig. 2). All twelve mesenteries are fertile in *H. arenarea*, apparently to an equal extent.

4. Suckers formed by outgrowths of the middle layer, coated by the ectoderm, occur in *H. arenarea* (Pl. XXXVI., fig. 9), but are absent in the other species.

Other less marked distinctions can be discovered on submitting the various organs and tissues to a rigorous examination.

PEACHIA, Gosse, 1855.

Halcampidæ, with column divisible into capitulum, scapus, and physa; column provided with numerous minute suckers; the capitulum retractile; no sharply defined circular muscle; a single deep œsophageal groove, which is continued as a tube to nearly the posterior end of the body; its oral end is produced into well-marked, often complicated, lobes (the conchula), of which one basal and two lateral elements can always be detected; tentacles twelve; physa perforated by very numerous apertures in twelve longitudinal rows; four pairs of short, sterile mesenteries present, in addition to the six pairs of perfect fertile mesenteries, situated in the lateral and sulcar exocœles; longitudinal muscles of all the mesenteries extremely well developed.

BRITISH SPECIES OF PEACHIA.

PEACHIA HASTATA, Gosse.
(,, UNDATA (?), Gosse). (Probably immature form of above.)
(,, TRIPHYLLA, Gosse).

The last two species have hitherto only been recorded from the Channel Islands.

Peachia hastata (Gosse).

This form occurs abundantly in a limited district in Dublin Bay. Mr. G. Y. Dixon and myself have given (A. C. Haddon and G. Y. Dixon, **1885**, p. 399) a short account of the history and habits of this interesting Actinian. The only accounts we have of its structure are—(1) a short notice by M. Faurot (**1884**, p. 756), and an allusion to the œsophageal groove by Mr. Sedgwick (**1884**, p. 84), who gives the only published figure (pl. ii., fig. 6) of any anatomical details. The figure represents an internal view of the upper portion of a partially dissected Peachia (sp. not stated).

The accompanying diagram represents the arrangement of the mesenteries and the general appearance of their enormously developed longitudinal muscles.

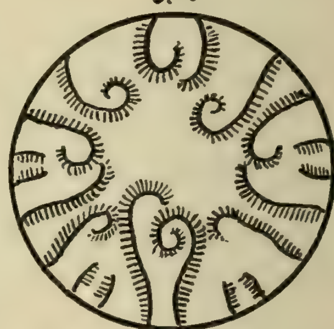


FIG. 1.—Diagrammatic section through *Peachia hastata.*

There are six pairs of perfect (*i. e.* those which reach the œsophagus) mesenteries arranged in the ordinary manner. In each lateral and sulco-lateral exocœle (inter-mesenteric chamber) there is a pair of small imperfect mesenteries, these also possess relatively very large longitudinal retractor muscles. Of the twelve perfect mesenteries, the sulcar directives are much larger than the others, and in the upper portion of the body, below the œsophagus, bear the ciliated groove. The sulcular directives appear to be smaller than the four pairs of lateral mesenteries. All the perfect mesenteries are fertile.

On a future occasion I hope to have more to say on this very interesting Actinian, but I may here remark, that I have a sketch of a conchula of a specimen not fully grown, which is practically identical with the woodcut Mr. Gosse gives ("Actinologia," p. 239) of his *P. undata*, and I am inclined to believe that the latter is but a half-grown *P. hastata.*

Several larval Actiniæ, together with the Leptomedusæ, on which they were parasitic, were given to me by my friend, Prof. W. C. M'Intosh, who obtained

them at St. Andrew's, Fife, Scotland, in 1887. The Actiniæ attach themselves to the upper or under surface of the bell, or to the margin, or to the gastric region of the Medusæ. (M'Intosh, **1887**.)

The Actiniæ from St. Andrew's are of slightly different ages: the youngest so exactly corresponds to the stage of *Halcampa chrysanthellum* previously described by me (**1887**, p. 473), that a further description would be superfluous. The slightly older larvæ are larger, the tentacles are longer, and new tentacles are making their appearance in the lateral endocœles. I am not yet in a position to state whether there is any particular order in their development.

At first sight these young Actiniæ bear an unmistakable resemblance to the larvæ of *Halcampa chrysanthellum* both externally and anatomically; so we may confidently consider them to be closely allied. The presence of twelve mesenteries precludes their being Edwardsiæ. The genera Peachia and Ilyanthus are usually associated with Halcampa: of the second of these I can say nothing, as it has never been anatomically described; besides, it is quite a rare form; but our larvæ are decidedly common. We then narrow the question to Halcampa and Peachia. Only two British species of Halcampa are known—*H. chrysanthellum* of North European distribution, and *H. arenarea* (*ante*, p. 335) from the south-west of Ireland. Of this only two specimens have been obtained. I have made sections through three parasitic larvæ of *H. chrysanthellum*, and am therefore well acquainted with it, and, although they agree perfectly with the forms from St. Andrew's in their general appearance and structure, still there are distinctions in their histology which cannot now be gone into. One point, however, deserves special mention, and that is the appearance of the longitudinal retractor muscle of the larger mesenteries. In the earlier stages of *H. chrysanthellum* the muscle is relatively more extended than in the adult, but the distal plications are of considerable length, and decidedly recall those of the adult. In a later stage this is naturally still more marked. The corresponding muscles in the St. Andrew's specimens is much less conspicuous; it extends for a greater distance across the mesentery, consequently the plications are more numerous, but, on the other hand, they are very much shorter and simpler than in *H. chrysanthellum*.

In transverse sections through *Peachia hastata* I find that the retractor muscles are greatly developed, forming a regular close-set fringe to the border of the mesentery, and thus constituting a type of muscle very different from the reniform section of the retractor in Halcampa. My material is at present insufficient to enable me to make a definite statement, but there is nothing in the character of the longitudinal muscles of the mesenteries antagonistic to the view that these are the young of *Peachia hastata*. The latter species, according to Prof. W. C. M'Intosh, is common in the neighbourhood. I would further point out that the larvæ from St. Andrew's, stage for stage, are decidedly larger than

those of the Halcampa which occurred to me: this would also correspond with the greater size of the adult Peachia over that of Halcampa.

A preliminary account of the above, with rough diagrams, has recently been published by myself (**1888** (A), p. 281; (B), p. 256).

The localities for *P. hastata* are—north of France, south of England, east of Ireland, and east of Scotland. The unique specimen of *P. undata* came from Herm, Channel Islands.

The remaining British species is *Peachia triphylla*, Gosse (*cf.* Gosse, Actinologia, p. 243, and Andres, Le Attinie, p. 109).

Actinia cylindrica, Reid (**1848**, Ann. Mag. Nat. Hist. (N.S.), I., p. 34), was called *Peachia cylindrica* by Mr. Gosse ("Actinologia," p. 245), and *Halcampa cylindrica* by Dr. Andres ("Le Attinie," p. 105). Mr. G. Y. Dixon and myself (**1885**, p. 400) have discussed its identity with *P. hastata*. As *A. cylindrica* was at the time pre-occupied, Mr. Gosse's name stands.

The synonymy of the Actiniæ which are found parasitic on various Medusæ, and which have been referred to the genera Bicidium, Philomedusa, Halcampa, and Peachia, has recently been discussed by me (**1887**, p. 473), and need not be here repeated.

Ilyanthus.

I have no knowledge of this genus.

GONACTINIA.

Although not recorded as British, I propose to give a brief account of *Gonactinia prolifera*, Sars, as it appears to constitute an interesting link in the series of forms we are now considering.

Gonactinia prolifera, Sars.

Actinia prolifera, n. sp., M. Sars, . . .	1835, Beskrivelser og Jagttagelser over nogle mærkelige eller nye i Havet ved den Bergenske Kyst levende Dyr, &c., Bergen, pp. 3, 11, pl. ii., fig. 6.
Gonactinia prolifera, M. Sars, . . .	1851, Nyt. Mag. f. Naturvid., vi., p. 142.
Gonactinia prolifera, Koren, . . .	1859, Nyt. Mag. f. Naturvid, ix., p. 93.
Gonactinia prolifera, Andres, . . .	1884, Le Attinie, p. 362.
Gonactinia prolifera, Blochmann and Hilger,	1888, Morph. Jahrb., xiii., p. 385, pls. xiv. and xv.

Habitat.—Coasts of Norway, from 2 to 20 faths.

Very recently Drs. Blochmann and Hilger (**1888**) have given a careful anatomical description of *Gonactinia prolifera*, Sars, and of its remarkable anular

method of reproduction by means of transverse fission or strobilisation. These authors find that there are sixteen mesenteries, eight of which reach the œsophagus ("macrosepta"), and the other eight do not ("microsepta"). Two pairs of directive mesenteries are present. Starting from what they identify as the dorsal (sulcular) directives, there are on each side a pair of microsepta. (?) Then follows a macroseptum, which, below the œsophagus, bears the "generative organs;" then a microseptum; next again a "fertile" macroseptum, followed by a microseptum; and lastly, there are the two sulcar ("ventral") directives.

The longitudinal, or retractor, muscles of the mesenteries are arranged in such a manner that the two microsepta on each side of the dorsal directives form a pair: two other pairs are formed by a macroseptum and a microseptum respectively. The accompanying diagram illustrates these facts.

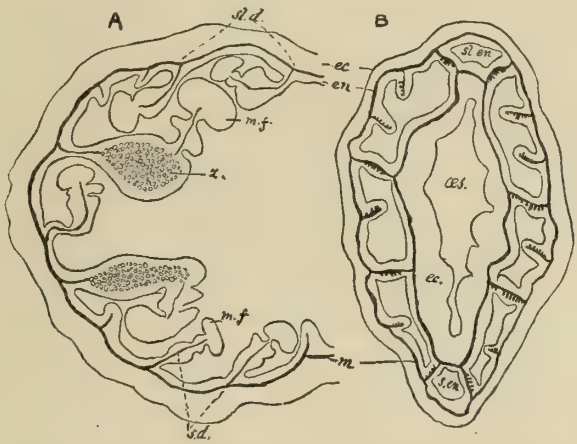


FIG. 2.—*Gonactinia prolifera* (after Blochman and Hilger).
A, half a transverse section below the œsophagus; B, transverse section through the œsophageal region.
(For lettering, see explanation of Plate XXXIV.)

Two œsophageal grooves are present. There are sixteen tentacles in two rows of eight each. "Septalstomata" or perforations in the mesentery appear to be absent. Acontia are also wanting. Length when extended 5 mm.

Drs. Blochmann and Hilger point out that we have in Gonactinia two mesenterial systems which may be compared together, but are inversely orientated. The one consists only of macrosepta, the other solely of microsepta. Each of them exhibits, in its own disposition of muscles, that which one finds in the Edwardsiæ. Later on they state that this Actinian cannot be placed in Prof. R. Hertwig's system ("Challenger" Report). Perhaps it had better be ranged near the Zoantheæ; it agrees with these in the presence of partition walls of two kinds, but is sharply separated from them by the possession of two œsophageal grooves. At all events a new tribe must be erected for it.

These authors' comparison of the mesenteries of Gonactinia with those of Edwardsia calls for remark. The agreement of the "macrosepta" with the mesenteries of Edwardsia is suggestive, but nothing appears to be gained by turning the animal round and seeing a similar agreement in the "microsepta."

I would rather suggest a comparison with the arrangement of the mesenteries which obtains in the young of several other Actiniæ (see p. 350). By comparing a diagram of the latter (Pl. XXXVII., fig. 7) with the one of Gonactinia (p. 341, fig. 2) it will be seen that there are only two points of difference—(1) the Halcampa larva has only one œsophageal groove (the ventral), and (2) the addition of a pair of weak mesenteries (microsepta) on each side of the pair of dorsal directive mesenteries. The lateral strong mesenteries in Gonactinia are alone "fertile," in *Halcampa chrysanthellum* (Pl. XXXV., fig. 1) these, with the ventral directive mesenteries, bear the gonads. It is questionable whether the possession of a mesenteric filament by the weak mesentery, between the two "fertile" mesenteries in Gonactinia, is of any special significance.

A pair of very small secondary imperfect mesenteries occur in the intermesenterial chambers of *Halcampa chrysanthellum* and *H. arenarea*, as in most other Actiniæ, but not in *H. clavus* (R. Hert., (?) of Q. & G.). The sulculo-lateral pairs of similar mesenteries in Gonactinia may for the present be regarded as being the equivalent of these, but of which only two pairs are developed. We have just seen that in *Peachia hastata* the lateral and sulco-lateral pairs of imperfect septa are alone present, so the occurrence of only sulculo-lateral pairs is not very anomalous. The only unique feature in this Actinian is the faculty of a sexual reproduction by means of transverse fission.

It will be seen from the above that I have mentioned the presence of generative organs in Gonactinia with doubt. An inspection of figure 2 will show that the character of what have been identified as the testes is very different from the testes as figured by the Brothers Hertwig, or in the accompanying plates (Pl. XXXV., figs. 2 & 6; Pl. XXXVI., fig. 7); and indeed from any Actinian generative organ with which I am acquainted. These bodies, however, are so similar in appearance and size to the commensal unicellular algæ (Zooxanthellæ), that Drs. Blochmann and Hilger must adduce conclusive evidence of their sexual nature before their view can be accepted. It is not unusual to find the algæ crowded in the same four mesenteries of the young of *Cereus pedunculatus* in the stage corresponding to that of the figured Gonactinia.

The minute size of Gonactinia is suggestive of immaturity, as adult Actiniæ are rarely very small. The arrangement of the mesenteries, as will be seen from what follows, also supports the view, that this may after all be an immature form: this is also confirmed by the character of its histology and the feeble development of the mesoglœa.

I am not prepared to say of what form Gonactinia is probably a larval stage, but would venture to suggest an investigation of the development of *Anemonia sulcata* (Penn.) = (*Anthea cereus*, Auct.), and of *Actinopsis flava* (Dan. & Kor.), the young forms of which are undescribed. An anatomical investigation of the latter species would be particularly interesting.

Zoantheæ.

Actiniæ, with numerous perfect and imperfect mesenteries; two pairs of directive mesenteries, of which the sulcar are perfect and the sulcular are imperfect. A pair of mesenteries occur on each side of the sulcular directives, of which the sulcular moiety is perfect and its sulcar complement is imperfect; a similar second pair occurs in one section of the group (Zoanthus), or the second pair may be composed of two perfect mesenteries (Epizoanthus). In all the remaining pairs of mesenteries this order is reversed, so that the perfect mesentery is sulcar and the imperfect sulcular. The latter series of mesenteries are bilateral, and arise independently (*i.e.* neither in pairs nor symmetrically on each side) in the exocœle on each side of the sulcar directives, in such a manner that the sulcular are the oldest and the sulcar are the youngest. The perfect mesenteries are alone fertile. A single sulcar œsophageal groove is present. Animals usually forming colonies; body-wall usually traversed by irregularly-branching ectodermal canals, and rendered rigid by grains of sand.

Prof. Dana (**1846**), and later, Dr. Andres (**1877**), and the Brothers Hertwig (**1879**), showed that the mesenteries of the Zoantheæ were arranged on a different plan from those of other Actiniæ, and demonstrated the occurrence of alternate perfect and imperfect mesenteries; but Prof. von Koch (**1880**) was the first to elucidate this arrangement in *Zoanthus* (*Palythoa*) *axinellæ*. Prof. R. Hertwig's "Challenger" Report was published in 1882, and threw much further light upon the anatomy of the Zoantheæ. Shortly afterwards Dr. G. Müller (**1883**) published his dissertation, in which he more or less fully describes fourteen species of Palythoa and Zoanthus. The last Paper on the subject is one by Dr. A. Erdmann (**1885**).

In this very important Paper Dr. Erdmann describes two species of Zoanthus, five species of Epizoanthus, three species of Palythoa, two species of Corticifera, one of Sphenopus, and an unnamed new genus: of these fourteen species only one, *Palythoa axinellæ*, Schmidt, is fully identified. The main facts relating to the arrangement of the mesenteries are as follows:—

Two kinds of mesenteries are present in the Zoantheæ—

1. Larger, or "macrosepta," bearing mesenterial filaments and generative

organs, which reach the œsophagus throughout its entire length, and are therefore "perfect."

2. Smaller, or "microsepta," without mesenterial filaments and generative organs, which, not reaching the œsophagus, are "imperfect."

A macroseptum and a microseptum together constitute a pair of mesenteries, as the sides which face each other bear a longitudinal muscle. Only two pairs form an exception, these are the pairs of directive mesenteries, situated one at each of the long axis of the œsophagus, and whose longitudinal muscles are on opposite sides of the mesenteries.

The œsophagus possesses but one œsophageal groove, the directive mesenteries of this pole being macrosepta, whereas those of the opposite side are microsepta.

In Zoanthus the pairs of mesenteries are arranged in two series—(*a*), on each side of the micro-directive mesenteries, and starting from them the first two pairs consist each first of a macroseptum and then of a microseptum; (*b*), the third and succeeding pairs each consist first of a microseptum, and then of a macroseptum, thus the pair of macro-directive mesenteries lie between two macrosepta. In Epizoanthus the arrangement is the same, except that the second pair of mesenteries is composed of two macrosepta, instead of a macroseptum and a microseptum. (See Diagrams, Pl. XXXVII., figs. 1 & 2.) Thus, in addition to the bilateral symmetry, which is discernible in all the Actiniæ, although superficially they appear to have a typical radial symmetry, we have in the Zoantheæ a division line at right angles to the sagittal axis, which demarcates the regions of the pairs of mesenteries just alluded to.

Prof. R. Hertwig has termed the micro-directive mesenteries "dorsal," and the macro-directives "ventral," and in this he is followed by Dr. Erdmann. As the former zoologist says, "We can therefore divide the ordinary pairs of 'septa' (mesenteries) into two different regions; in the one (the larger or ventral region) the ventral septa of the single pairs are macrosepta, and the dorsal septa are microsepta, whilst in the other (the dorsal region) the reverse is the case, and the dorsal septa are macrosepta" ("Challenger" Report, p. 110).

From the foregoing description it will be seen that there are two types of arrangement—the one in which the sulcular ("dorsal") region is separated from the sulcar ("ventral") by two imperfect mesenteries (Pl. XXXVII., figs. 1 & 2); and the other in which the two regions are divided by two perfect mesenteries: the former type is termed by Dr. Erdmann the "microtypus," the latter the "macrotypus."

I object to use the terms "macro-" and "micro-septa," not only because they are hybrid words, but on account of the use of the word "septum," which, as I have previously stated, should be retained for the calcareous partitions of the

corals. There is, moreover, no need to introduce a new term when we already possess the equivalent in "perfect" and "imperfect" mesenteries.

As Dr. Erdmann also points out, in Actiniæ the development of the mesenteries falls into two periods. The first, in which there are six perfect pairs, including the two pairs of directives. In the second period, in the majority of Actiniæ, the other mesenteries successively appear in pairs in the centre of each intermesenterial chamber (exocœle); but never in an intramesenterial chamber (endocœle). These constitute the mesenteries of the second, third, &c., order.

It is in the second period that the order of origin of the mesenteries is different in the Zoantheæ; for here the new mesenteries are formed only in the intermesenterial chambers which lie immediately on each side of the sulcar ("ventral") directive mesenteries. The perfect mesenteries and imperfect mesenteries are developed independently of each other, and not necessarily symmetrically. From this it follows that—taking the sulcar region into consideration only—the most sulcular mesenteries are the oldest; those nearest the sulcar directive are the youngest, the mesenteries appearing singly, and not in pairs, and, lastly, there may be more on one side than on the other (see Pl. xxxvii., fig. 3).

We may put this another way, by saying that in the majority of Actiniæ the new pairs of mesenteries appear radially in all the exocœles, whereas in the Zoantheæ they appear laterally in the sulcar exocœles.

At a very young stage, that is, in the first period, only the two pairs of directives, and the sulcular pairs of mesenteries are present, but the distinction noted above still obtains. (See diagrams, Pl. xxxvii., figs. 4 & 5). Dr. Erdmann terms these young stages, respectively, the "microgrundform," and the "macrogrundform."

We are justified in assuming that the sole distinction between these two types is, that in the "macrotypus" the second lateral perfect mesentery (that is, the sulcar element of the sulco-lateral pair of the ground-type) on each side has developed into a perfect mesentery. If this be so, Prof. Hertwig was mistaken in supposing that in this group two imperfect mesenteries are wanting between the sulculo-lateral pair of perfect mesenteries.

We are now in a position to discuss the probable relationships of the Zoantheæ. On comparing a diagrammatic section, through a young microtype form (*e. g.* Zoanthus) with a similar section through a larval Halcampa, we find an absolute identity in the disposition of the mesenteries, with the single exception of the sulcular directives, which are imperfect in the Zoantheæ, but perfect in Halcampa, although both in the young form and the adult they are perceptibly weaker than the other eight perfect mesenteries (diagrams, Pl. xxxvii., fig. 7, A & B). The sulcar œsophageal groove alone is present, and, lastly, in the adult, *H. chrysanthellum*, it is only those mesenteries which correspond with the perfect mesenteries

of, say, Zoanthus, which are fertile, and it must be remembered that only the perfect mesenteries of the Zoantheæ are fertile.

Accepting the arrangement of the mesenteries as a clue to affinity, and, as a matter of fact, we have little else to guide us, we may safely assert the relationship of the young Zoantheæ with the young of several different forms of Actiniæ, as I shall show. The adults constitute a very distinct subdivision of the Actiniæ, owing to the unique method in which the new mesenteries make their appearance. The very general possession of ectodermal canals in the body-wall and of asexual reproduction by means of buds from a stolon serve to accentuate their distinctness.

I have not yet had time to sufficiently study the British species of Zoantheæ from an anatomical or from a synonymic point of view.

DEVELOPMENT OF ACTINIÆ.

With the exception of an important Paper by Prof. H. de Lacaze Duthiers (**1872**), very little has been done to elucidate the developmental history of Actiniæ. So far as they go the researches of the above author are most precise, and are illustrated by beautiful figures. The facts elucidated are very remarkable, and are not at all what would, *a priori*, be expected to occur in a hexamerous Actinian. The investigations mainly concern the order of appearance of the mesenteries and tentacles: the former will first occupy our attention.

Prof. de Lacaze Duthiers studied the following species:—*Actinia equina*, *Cereus pedunculatus* = (*Sagartia bellis*); *Cylista undata* = (*S. troglodytes*); and *Bunodes verrucosa* = (*B. gemmacea*).

The following brief abstract refers to the first species:—

Actinia equina.

1. The cavity (cœlenteron) of the larva is divided into two unequal chambers by two small mesenteries which arise transversely to the long axis of the œsophagus. The larger chamber will be referred to by *a′*, the smaller by *a* (Pl. XXXVII., fig. 8).

2. A second pair of mesenteries is next formed in the chamber *a′*, dividing it into a larger terminal chamber (*a′*), and a lateral small chamber (*b*) on either side (Pl. XXXVII., fig. 9).

3. In the next stage chamber *a* is similarly divided into a terminal chamber (*a*), and into a pair of lateral chambers (*c*). Following so closely upon this as to almost occur at the same time, the chamber *b* of each side is subdivided into *b* and *d* by the formation of mesentery No. 4 (Pl. XXXVII., fig. 10).

The first and second pairs of mesenteries to appear are also the first which reach the œsophagus: shortly later the third and fourth pairs also join (Pl. xxxvii., fig. 11).

4. The chambers *d* are next divided into *d* and *e* by No. 5 mesentery, and this is closely followed by the division of *c* into *c* and *f* by the 6th pair of mesenteries (Pl. xxxvii., fig. 12). These two new pairs of mesenteries are at first quite short, and do not possess the mesenterial filaments which characterise the other mesenteries. Of the latter, the first pair to appear still maintains its prominence by having very large craspeda: they were also the first mesenteries to obtain them (Pl. xxxvii., fig. 13).

Later, the fifth and sixth pairs of mesenteries reach the œsophagus, so that there are now twelve perfect mesenteries, which fall into the ordinary Actinian arrangement of two pairs of directives and two pairs of lateral mesenteries. It must be borne in mind, that in the description of the order of the mesenteries, the "pairs" spoken of merely referred to the synchronous appearance of two corresponding mesenteries on each side of the axial line, and not two pairs of complementary mesenteries.

At a later stage each exocœle is divided by a pair of mesenteries in the usual manner, but in a slightly older larva, figured by Prof. de Lacaze Duthiers, the two exocœles on each side of the axial endocœle *a′* have each originated a pair of small mesenteries.

Concerning the third stage in the order of appearance of the mesenteries, our author says (*l. c.*, p. 331): "One may see from the preceding paragraph, that it is difficult to establish the succession of the partitions of the third and fourth formation. It is only when they are well marked, that one can recognize that the one is more developed than the other. It results from this—an obviously very remarkable fact—that the period when the number six occurs is very quickly passed over, very fugitive . . . If then the period of four chambers is very evident and easy to establish, the period of the number of eight is not less so."

It is during the octoradiate stage that the tentacles first appear. The earliest to appear sprouts from the terminal chamber *a′*, and until the twelve-rayed stage has become well established this tentacle is markedly larger than the others. Of the remaining seven tentacles, those corresponding to the median lateral chambers (*d*) are next largest. The axial tentacle *a* and the other four tentacles are much smaller, being scarcely more than tubercles (Pl. xxxvii., fig. 14, A, B, & C).

In the next stage, the axial tentacles (*a′* and *a*) and the three central lateral ones (*d*, *e*, *f*) are large and of the same size, except *a′*, which is still the largest: the remaining four tentacles, corresponding to the exocœles on each side of the directives, remain rather small.

The order of development of the mesenterial filaments is as follows:—(1) The first pair of mesenteries; (2) the fourth pair; (3) the second and third pair

practically simultaneously; (4) the fifth and sixth pairs of mesenteries acquire their craspeda somewhat later.

These three organs—mesenteries, tentacles, and craspeda—appear in pairs relative to the axis of the body, and not in the least corresponding to the paired radial symmetry of the adult. In other words, the early larva are bi-laterally symmetrical, and it is only on the completion of the stage with twelve perfect mesenteries that the young definitely acquires the radial symmetry of the adult. The tentacles, however, continue to develop in an apparently anomalous manner, which need not now detain us: on the completion of the number twenty-four they are arranged in the cycles typical of the Actiniæ, viz., 6 + 6 + 12. Another period of irregular appearance occurs, but when the forty-eight stage is established, the radial symmetry again becomes predominant, and we have 6 + 6 + 12 + 24. In this and in the preceding stage the tentacles do not appear in the order which their size or their cycle would indicate: thus we have the tentacles of a sextant arranged as follows:—

Cycle, . .	I.	IV.	III.	IV.	II.	IV.	III.	IV.	I.
Appear., .	1	4	4	3	3	2	4	4	1

The marginal spherules which characterise this species appear at the twelve-rayed stage.

The first two mesenteries to appear, that is those which primitively divided the embryo into moieties, can, by their size, be continued to be recognized, until the period when the young Actinia has twenty-four tentacles: thus it is possible up to this stage to recognize the elements dependent on each of the two primitive moieties.

Cereus pedunculatus (*Sagartia bellis*).

The formation of the mesenteries and tentacles in this form exactly recapitulates that of *Actinia equina*. At the stage of twenty-four tentacles, acontia are formed by the edges of the two mesenteries which first make their appearance, becoming detached and floating freely in the cœlenteron. As in the above example, the same mesenteries first acquire craspeda, very shortly afterwards the fourth pair also develop them. This preponderance of the first four filaments is early apparent, and persists until the twelve-rayed stage is passing away, when the directive mesenteries acquire their mesenterial filaments, which soon outstrip the others in size.

Cylista undata (*Sagartia troglodytes*).

The development of this Sagartid precisely resembles that of the foregoing.

Bunodes verrucosa (*B. gemmacea*).

The order of development of the mesenteries and tentacles is the same as above, but it appears that Bunodes remains longer in the octoradiate stage than the preceding species (Pl. xxxvii., fig. 15). As before, this number eight is decomposable into three and five, on account of the position of the first pair of mesenteries. The four new tentacles to complete the twelve arise from the chambers *c* and *e* (compare diagram, Pl. xxxvii., fig. 16).

The mesenterial filaments at first appear on the two oldest pairs of mesenteries, *i. e.* 1 and 2: later they occur on the mesenteries of the fourth age (Pl. xxxvii., fig. 16).

Professor A. Kowalevsky has published some observations on an undetermined species of Actinian. The first two mesenteries appear at the same time that the lips of the blastopore are invaginated, to form the œsophagus (stomatodæum). A pair of mesenteries then appear in each of the two chambers, into which the cœlenteron is divided by the first pair. So far the order agrees with that described above for *Actinia equina*, but instead of a pair of mesenteries arising laterally, an unpaired mesentery is formed in one axial chamber, and shortly afterwards one arises in the opposite axial chamber: thus a stage with eight mesenteries is also developed.

The Brothers Hertwig (**1879**) describe three stages in the development of *Adamsia diaphana*, the earliest of which already possessed twelve mesenteries (diagram, Pl. xxxvii., fig. 17, A & B). In their second stage the outer mesenteries of the four short lateral mesenteries have grown considerably, and developed their longitudinal muscles. They are now seen to be the complements of the four perfect lateral mesenteries, and later they too reach the œsophagus, and complete the six pairs of primary perfect mesenteries. In the last stage the pairs of mesenteries of the third and fourth cycle have appeared in the exocœles in the ordinary manner.

The only account we possess of the development of the mesenteries in Edwardsia is the preliminary publication of some drawings in the "Selections from Embryological Monographs" (**1884**), of an unpublished Paper by Dr. E. L. Mark. The form studied was, perhaps, *Edwardsia lineata*, Verr., which, in its earlier stages, is parasitic in the Ctenophore *Mnemiopsis leidyi*. Two mesenteries first

appear: these are the sulco-lateral, or, according to the ordinarily received terminology, the ventro-lateral. The right sulco-lateral mesentery ends somewhat abruptly before reaching the aboral pole. In a transverse section made at an early stage depressions in the surface of the endoderm show the places where the mesenteries will appear. The depressions corresponding to the sulculo-lateral mesenteries are most evident; those of the sulcar pair are less distinct, but those of the sulcular pair are not indicated. In a slightly later stage the sulcular mesenteries have made their appearance, the sulco-lateral are relatively very large, and their terminal filaments are very conspicuous. The other six mesenteries are quite small, and appear to be uniform in size. In the upper portion of the body all eight mesenteries reach the œsophagus, and the rudiments of their longitudinal muscles are visible. These have the arrangement characteristic of Edwardsia.

In the brief abstract just given of Prof. de Lacaze Duthiers' researches, his account has been given without comment, and his numeration of the mesenteries and lettering of the mesenteric chambers has been adhered to. According to the system of nomenclature which I now propose, the development of the mesenteries is as follows:—1. Sulcular sulco-laterals; 2. sulcular directives; 3. sulcar directives; 4. sulcular sulculo-laterals; 5. sulcar sulculo-laterals; 6. sulcar sulco-laterals. The chambers being *a*, sulcar endocœle; *a'* sulcular endocœle; *b*, sulcular exocœle; *c*, sulcar exocœle; *d*, sulculo-lateral endocœle; *e*, lateral exocœle; *f*, sulco-lateral endocœle.

When these researches were published attention had not been called to the importance of the position of the longitudinal retractor muscle of the mesenteries in the morphology of the Actiniæ, and Prof. de Lacaze Duthiers makes no mention of this structure. The identity of the general disposition of the mesenteries and their relative size had led me to regard the fourth stage of the above account as being in every way comparable with the larva of *Halcampa chrysanthellum* which I have previously described (1887). At my suggestion, my pupil, Mr. Francis Dixon, has commenced an investigation upon the embryology of Actiniæ, and he has kindly permitted me to anticipate some of the results he has arrived at. Mr. Dixon has cut transverse sections of larvæ of Prof. de Lacaze Duthiers' three types, viz. *Actinia equina*, *Cereus pedunculatus*, and *Bunodes verrucosa*, with the anticipated result. In these representative species of three different families of Actiniæ, the development of the mesenteries is similar in all, both as regards the order of their appearance and the disposition of their muscles, and they are also identical with those of the larva of Halcampa (I am now confining myself to the first six pairs of mesenteries, which probably, alone, are of primary importance).

The only definite observation which is opposed to this statement is that of the Brothers Hertwig (1879). Their account of the disposition of the mesenteries in

Adamsia diaphana has already been given. In order to bring Prof. de Lacaze Duthiers' description into harmony with their observation, they assume that the French zoologist has mistaken the order of appearance of his second and fourth pairs of mesenteries. By interchanging these two numbers, and by supposing that the longitudinal muscles of the first and second (according to them) mesenteries face one another, they bring the older account into accord with the eight perfect mesenteries of their first stage. With all due deference to the distinguished German zoologists, it seems to be somewhat unfair to throw doubt upon the very careful and minute investigations of Prof. de Lacaze Duthiers, and it affords me great pleasure to be able to corroborate and extend the observations of the illustrious French savant. *Adamsia diaphana* is a Sagartian, as is also *Cereus pedunculatus*, and it requires to be studied anew, especially its earlier stages.

GENERAL CONSIDERATIONS.

The following deductions, based upon embryological and anatomical evidence, appear to be warranted by the present state of our knowledge :—

1. In larval Actiniæ two mesenteries arise at right angles to the long axis of the œsophagus, and divide the archenteron (cœlenteron) into two chambers.

These two chambers are unequal in *Actinia equina*, *Cereus pedunculatus*, *Cylista undata*, *Bunodes verrucosa*, and *Edwardsia lineata*, (?) and possibly also in *Cerianthus membranaceus*, and in *Actinia* sp. (Kowalevsky).

2. A pair of mesenteries appears in the larger of the two primitive chambers of the cœlenteron. Apparently this stage is common to all investigated Actiniæ; but as no observations have been made on the mesenteries of Cerianthus beyond the first stage, it must be left out of consideration.

3. A third pair of mesenteries develops in the smaller of the two primitive chambers. Immediately afterwards another pair of mesenteries appears.

In the first four species the fourth pair of mesenteries arises between the first and second, that is, in the lateral chambers of the larger of the primitive divisions of the cœlenteron; but in *Edwardsia lineata* (?) the new pair appears within the single or terminal chamber of the same division. Prof. Kowalevsky's account of

the development of the seventh and eighth mesenteries cannot be brought into harmony with the preceding.

A short resting stage now occurs in which eight mesenteries are alone present, and the corresponding chambers of the cœlenteron are produced into eight tentacles.

This appears to be a characteristic phase in the development of all the Actiniæ hitherto studied, with the exception of Cerianthus. There is now evidence to support the conclusion that in most, and probably in all other larval Actiniæ, these eight mesenteries are homologous with those of the Edwardsiæ. In other words, such forms as Halcampa, Actinia, Cereus, Bunodes, and probably many, if not all other sea-anemones (except Cerianthus), pass through a larval stage, which is permanently retained in the adult Edwardsiæ.

4. The next stage is characterized by the practically simultaneous development of two pairs of mesenteries: these for some time remain imperfect: their longitudinal muscles face those of the first and fourth mesenteries respectively.

This condition exists in *Gonactinia prolifera*, and practically permanently in the Zoantheæ, although in the Epizoanthus group the equivalent of the sixth pair of mesenteries reach the œsophagus. The terminal zone of mesenteric development is a special feature added on to the above arrangement. This fourth stage occurs for a long time in the larva of Halcampa, but it is more rapidly passed over in the four species described by Prof. de Lacaze Duthiers.

5. The fifth and sixth pairs of mesenteries now reach the œsophagus, and constitute the ground or fundamental form of the typical hexamerous Actiniæ. Twelve tentacles also appear, which usually range themselves in two series, those belonging to the six endocœles being usually more prominent than the others.

The adults of Halcampa, Peachia, the Sagartidæ, and the groups which receive *Actinia equina* and *Bunodes verrucosa*, pass through this stage. The Halcampa, described by Prof. R. Hertwig as *H. clavus* (1882), does not advance further.

6. A pair of small mesenteries, with their longitudinal muscles facing one another, is developed in each exocœle.

This is the permanent condition of *Halcampa chrysanthellum* and *H. arenarea*, except that the longitudinal muscles are undeveloped. In the adult of *Peachia hastata* strong longitudinal muscles are developed on the new small mesenteries, but only four pairs of mesenteries are formed. Those corresponding to the sulcular exocœl (chamber *b* of diagram, Pl. XXXVII., fig. 12) are absent. The other hexamerous Actiniæ mentioned above pass beyond this stage.

7. These mesenteries grow larger, and other pairs appear successively in every exocœle until a considerable number is formed.

Amongst the family Sagartidæ the members of the sub-family Chondractininæ are characterized by the six primary pairs of mesenteries alone reaching the œsophagus, the six pairs of the second cycle, those referred to in the preceding paragraph (6), are imperfect, although mesenteries of the third, fourth, and even of the fifth cycle may be present. In the sub-family Sargartinæ, however, the mesenteries of the second cycle and those of other cycles may, in a more or less irregular manner, reach the œsophagus. In other Actiniæ all the mesenteries may be perfect.

As has been pointed out by other authors, we have the remarkable fact that in the early development of the Actiniæ the six-rayed arrangement of parts does not occur, typical as it is of the adults, although it is not so universal as is popularly imagined. As the late Prof. F. M. Balfour pointed out (1880, p. 140) the number of mesenteric chambers increases in arithmetical progression up to a certain stage; thus we have for both mesenteries and their chambers the numbers 2, 4, 6, 8, 10, 12, but of these the numbers 2, 4, 8, 12, are of chief importance, and alone appear to possess any phylogenetic significance.

I am not aware of any adult Hydroid-like organism which possesses a pair of mesenterial ridges and two tentacles.

The relationship of the Hydra-tuba and Scyphostoma stages of the Scyphomedusæ (Acalephæ) to the Zoantharia is now generally admitted, indeed a group (Tæniolatae) has been erected by Professor E. Hæckel to include them both. Later Professor A. Göette (1887) has similarly proposed the term Scyphozoa for the same assemblage, but including the Ctenophora, as opposed to the remaining Cœlenterata or Hydrozoa. The Scyphostoma have an œsophagus lined by ectoderm (Stomodæum), four glandular mesenteries, the edges of which are true craspeda, and serve to digest food; in their upper portion nematocysts are present. The four tentacles are afterwards increased to eight, and finally to sixteen. It is especially noteworthy that at first there are only two tentacles: probably this is a reminiscence of a remote ancestor. The widespread occurrence of a symmetry of four amongst the larvæ of the Scyphozoa is very suggestive.

One is tempted to recall the tetrameral symmetry of the Rugose Corals (Tetracoralla), as indicative of relationship to some primitive Scyphozoon, but for the warning of Mr. J. J. Quelch (1886, p. 42), who says:—"Thus, as the result of the foregoing considerations, there is not a single characteristic of the old group Rugosa which will essentially separate its forms from the more typical Astræids; and a direct expression is given to this fact by placing the families of the old Rugosa (except the family Cyathaxonidæ, which has been placed under the sub-section Turbinolida) with the family Astræidæ, under the sub-section Astræida."

A permanent octoradiate condition occurs in Edwardsia; but it is difficult to see where the Octocoralla (Alcyonaria) fit in; most probably they diverged much earlier from the Scyphozoon stock.

The passage from an eight-rayed to a twelve-rayed symmetry has already been fully described.

The following table illustrates the foregoing conclusions. It is designed to illustrate various stages of development of certain Actiniæ, but not to assert a phylogeny.

The time has not yet arrived when we can construct a classification of the Actiniæ as a whole.

Stages of development in terms of mesenteries.	Table of lines of development of certain Actiniæ.					
12 + 12 24, &c.					Typical hexameral Actiniæ	
12 + 12			Peachia	Halcampa	(*young*)	
12				Halcampa	(*young*)	
8 + 4			Gonactinia	(*young*)	(*young*)	—Zoantheæ.
8		Edwardsia	(*young*)	(*young*)	(*young*)	
4	Scyphostoma larva,	(*young*)	(*young*)	(*young*)	(*young*)	
2	(*young*)	(*young*)	(*young*)	(*young*)	(*young*)	—Ceriantheæ ?

Above the black line new mesenteries arise in pairs within each exocœle, or radially.

Below the line the mesenteries appear bilaterally with respect to the long axis of the œsophagus.

The order of development of the mesenteries, later than those of their respective fundamental forms in both the Ceriantheæ and the Zoantheæ is also bilateral.

BIBLIOGRAPHY.

1766. PENNANT:
A British Zoology: London.

1767. C. LINNE:
Systema Naturae. Edit. xii.

1776. O. F. MÜLLER:
Zoologiæ Danicæ Prodromus.

1780. O. FABRICIUS:
Fauna Grönlandica.

1786. J. ELLIS (THE LATE):
The Natural History of many curious and uncommon Zoophytes, etc., arranged by the late Dan. Solander: London.

1788–93. J. F. GMELIN:
C. Linné, Systema naturæ, etc. Edit. xiii.

1806. O. F. MÜLLER:
Zoologia Danica.

1815. L. OKEN:
Lehrbuch der Naturgeschicte: Jena.

1830. H. M. BLAINVILLE:
Dictionnaire des Sciences naturelles.

1830. H. M. BLAINVILLE:
Manuel d'Actinologie et Zoophytologie.

1834. H. EHRENBERG:
Beiträge zur physiologischen Kenntniss der Korallenthiere im Allgemeinen und besonders des Rothen Meeres, nebst einem Versuche zur physiologischen Systematik derselben. (Abhandl. d. Konig, Akad. d. Wissenschaft. Berlin. aus d. Jahre, 1832 (published in 1834), pp. 225–432.)

1835. J. F. BRANDT:
Prodromus descriptionum animalium ab H. Mertensio in orbis terrarum circumnavigatione observatorum. (Also in Ann. Sci. Nat., v. (1836) pp. 180–188.)

1835. M. SARS:
Beskrivelser og Jagttagelser over nogle mœrkelige eller nye i Havet ved den Bergenske Kyst levende Dyr, etc.: Bergen.

1842. A. DE QUATREFAGES :

Memoire sur les Edwardsies, nouveau genre de la famille des Actinies. (Ann. des Sci. Nat. Zool., ser. II., vol. xviii., p. 65.)

1846. J. D. DANA :

Report on Zoophytes, U. S. Explor. Exped., 1838–42, with Atlas.

1848. J. DALYELL :

Rare and remarkable Animals of Scotland.

1851. W. P. COCKS :

Actiniæ procured at Falmouth. (Nineteenth Ann. Rep. Roy. Cornwall Polytech. Soc., pp. 3–11, pl. ii.)

1851. M. SARS :

Beretning om en i sommeren 1849 foretagen Zoologisk Reise i Lofoten og Finmarken. (Nyt. Mag. Naturvid. vi., pp. 122–211.)

1853. P. H. GOSSE :

On new or little-known Marine Animals (*Actinia miniata*, *A. clavata*, *Ilyanthus mitchelii*). (Ann. Mag. Nat. Hist., ser. II., vol. xii.. pp. 125–128, p. 157; pl. x.)

1856. P. H. GOSSE :

On *Edwardsia carnea*, a new British Zoophyte. (Ann. Mag. Nat. Hist. ser. II., vol. xviii., p. 219 ; pl. ix., figs. 1–4.)

1857. H. MILNE EDWARDS :

Histoire naturelle des Coralliaires ou Polypes proprement dits.

1858. P. H. GOSSE :

On the British Actiniæ. (Ann. Mag. Nat. Hist., ser. III., vol. i., p. 414.)
Characters and descriptions of some new British Sea-anemones. (Ann. Mag. Nat. Hist., ser. III., vol. ii., p. 192.)

1858. W. THOMPSON :

Remarks on the British Actinidae and re-arrangement of the genera. (Proc. Zool. Soc., vol. xxvi., p. 145; also in Ann. Mag. Nat. Hist., ser. III., vol. ii., p. 229.)

1859. P. H. GOSSE :

Characters and Descriptions of some British Sea Anemones. (Ann. Mag. Nat. Hist., ser. III., vol. iii., p. 47.)

1859. J. KOREN :

Indberetning til Collegium academicum over en på offentlige Bekostning foretagen Zoologisk Reise i Sommeren, 1857. (Nyt. Mag. f. Naturvidensk, ix., p. 93.)

1860. P. H. GOSSE:
Actinologia Britannica: A History of the British Sea Anemones and Corals: London.

[This work was originally published in parts, the parts appearing as follows on the first day of the respective months:—

Part i.,	pp. 1–32,	March, 1858.		Part viii.,	pp. 225–256,	May, 1859.
,, ii.,	pp. 33–64,	May, ,,		,, ix.,	pp. 257–288,	July, ,,
,, iii.,	pp. 65–96,	July, ,,		,, x.,	pp. 289–320,	Sept., ,,
,, iv.,	pp. 97–128,	Sept., ,,		,, xi.,	pp. 321–352,	Nov., ,,
,, v.,	pp. 129–160,	Nov., ,,		Preface,		Dec., ,,
,, vi.,	pp. 161–192,	Jan., 1859.		Part xii.,	pp. 353–362,	Jan., 1860.
,, vii.,	pp. 193–224,	March, ,,				

I have deemed it advisable to give the dates of publication of these parts, as it will clear up some otherwise inexplicable facts of contemporary literature; for example, species apparently described by Mr. Gosse in 1860 are alluded to by authors in 1858. I gather from Mr. Gosse that only the first four parts were dated. As the date was only on the temporary cover, and not in the letterpress, all the species described in this work must date from 1860, the date on the title-page of the book when complete.]

1860. C. LÜTKEN:
Nogle Bemärkinger om de ved de danske Kyster iagttagne Arter af Aktiniernes Gruppe. (Vidensk. Meddel. Naturhist. Foren. Kjobenhavn., p. 184.)

1861. T. HINCKS:
Catalogue of the Zoophytes of South Devon and South Cornwall. (Ann. Mag. Nat. Hist. ser. III., vol. viii., pp. 152, 251, 290, 360.)

1864. A. E. VERRILL:
Revision of the Polypi of Eastern Coast of the United States. (Mem. Soc. Nat. Hist. Boston, vol. i. Read 1862, published 1864.)

1865. W. C. M'INTOSH:
Note on two new species of Edwardsia. (Proc. Roy. Soc. Edinb., vol. v., p. 394; also in Marine Intertebrate Fauna of St. Andrews (1875), pp. 37, 38; pl. ii., figs. 1–7.)

1868. A. M. NORMAN:
Shetland Final Dredging Report, pt. ii. (Rep. Brit. Assoc., 1868, pp. 232–345.)

1869. A. E. VERRILL:
Notes on Radiata. No. 6. Review of the Corals and Polyps of the West Coast of America. (Trans. Connect. Acad., vol. i., 1867–1871.)

1872. G. J. ALLMAN:
On the Structure of Edwardsia. (Quart. Journ. Micr. Sci., vol. xii., p. 394; also in Rep. Brit. Assoc., vol. xlii. (1872), p. 132.)

1872. H. DE LACAZE-DUTHIERS:
Developpement des Coralliaires: Actiniaires sans Polypier. (Arch. Zool. Exper. et gener. tom. i.)

1873. K. MOBIUS:
Jahresb. d. Commission z. wiss. Untersuch. d. Deutschen Meere in Kiel. 1871. (Abstract in Ann. Mag. Nat. Hist., ser. IV., vol. xiii., 1874, p. 203.)

1873. A. E. VERRILL:
Brief Contributions to Zoology: Dredging on the Coast of New England. (Amer. Jour. Sci. ser. III., vol. v., p. 1., and vol. vi., p. 440.)

1874. S. F. SMITH AND O'HARGER:
Report on the Dredgings in the region of St. George's Bank in 1872. (Trans. Connect. Acad., vol. iii.)

1874. A. E. VERRILL:
Brief contribution to Zoology from the Museum of Yale College, No. 28. Results of recent dredging expeditions on the coast of New England, No. 6. (American Journal of Science, ser. III., vol. vii., pp. 405, 498; pl. vii., fig. 7.)

1875. P. FISCHER:
Recherches sur les Actinies des cotes océaniques de France. (Nouvelles Archives du Muséum d'Hist. Nat. de Paris; tom. x., p. 193.)

1875. C. LÜTKEN:
Arctic Manual and Instructions, p. 186.

1875. F. E. SCHULZE:
Jahresb. Com. Untersuch. Deutschen Meere in Kiel. Exped., 1872.

1876. A. M. NORMAN:
Report "Valorous" Expedition. (Proc. Roy. Soc., vol. xxv., No. 173, p. 202.)

1877. A. ANDRES:
On a New Genus and Species of Zoanthina Malacodermata (*Panceria spongiosa*, sp. n.). (Quart. Journ. Micr. Sci. (N. S.), vol. xvii., p. 221, pl. xvi.)

1878. T. STUDER.
Zweite Abtheilung der Anthozoa polyactinia welche während der Reise S. M. S. Corvette Gazelle um die Erde gesammelt werden. (Monatsber, Königl. preuss. Akad. der Wissensch. Berlin., pp. 524–550, pls. i.–v.)

1878. G. VON KOCH:
Mittheilungen über Coelenteraten *Gephyra dohrnii*. (Morph. Jahrb., iv., pp. 74–87.)

1879. O. and R. HERTWIG:
Die Actinien anatomisch und histologisch mit besonderer Berücksichtigung des Nerven-Muskelsystems untersucht: Jena.

1880. F. M. BALFOUR:
A Treatise on Comparative Embryology: London.

1880. G. VON KOCH:
Notizen über Korallen. (Morph. Jahrb. vi., p. 355, tom. 16.)

1880 A. A. ANDRES:
Intorno all' *Edwardsia claparedii* (*Halcampa claparedii*, Panc.). (Atti R. Accad. Lincei, Roma, 3ª, V.; also in Mittheil. Zoolog. Stat. Neapel., II., p. 123.)

1880 B. A. ANDRES:
Prodromus neapolitanæ actiniarum faunæ addito generalis actiniarum bibliographiæ catalogo. (Mittheil. Zoolog. Stat. Neapel., II., p. 305.)

1882. R. Hertwig:

Report on the Actiniaria. (Report on the Scientific Results of the Voyage of H. M. S. "Challenger" during the years, 1873–76. Zoology, vol. vi., part 15.)

1882. A. F. Marion:

Actiniaires atlantiques des dragages de l'aviso le Travailleur. (Comptes rendus, xciv, p. 488; translated in Ann. Mag. Nat. Hist., ser. v., vol. ix., 1882, p. 406.)

1882. A. E. Verrill:

Notice of the remarkable Marine Fauna occupying the outer banks of the Southern Coasts of New England. No. 3. (Contributions to Zoology, Yale College, No. 49; Amer. Jour. Sci., ser. iii., vol. xxxiii., p. 135.)

1883. S. J. Hickson:

On the ciliated Groove (Siphonoglyphe) in the Stomatodæum of the Alcyonarians. (Phil. Trans., p. 693, pls. l., li.)

1883. A. Milnes Marshall:

Report on the Pennatulidæ dredged by H.M.S. "Triton." (Trans. Roy. Soc., Edinb., vol. xxxii., p. 125.)

1883. G. Müller:

Zur morphologie der scheidewände bei einigen Palythoa und Zoanthus. Marburg. (Dissertation for Doctor's degree, privately printed.)

1883. A. E. Verrill:

Bull. Mus. Comp. Zool. xi., pp. 45-62, pls. v.–viii.

1884. A. Andres:

Le Attinie. Fauna u. Flora d. Golfes v. Neapel, ix., Leipzig. As a matter of fact this monograph was published, in 1883, in the Atti R. Acad. dei Lincei, Rome (3 A), xiv. I have quoted from the separately published edition, as it is probably the one which will be in most general use. The pagination of the Roman Academy's Transactions is of course different.

1884. J. V. Carus:

Prodromus Faunæ Mediterraneæ.

1884. M. Faurot:

Sur l'anatomie de la *Peachia hastata.* (Comptes rendus xcviii., p. 756; translated in Ann. Mag. Nat. Hist., ser. v., vol. viii., p. 417.)

1884. E. L. Mark:

Selections from Embryological Monographs, iii., Polyps. (Mem. Mus. Comp. Zool., ix., No. 3, Harvard Coll. Cambridge, Mass.)

1884. A. Sedgwick:

On the origin of Metameric Segmentation and some other Morphological Questions. (Quart. Journ. Micr. Sci. (N. S.) xxiv., p. 43.)

1885. A. Erdmann:

Ueber einige neue Zoantheen. Ein Beitrag zur anatomischen und systematischen Kenntniss der Actinien. (Jenaische Zeitschr. Naturwiss. xix., p. 430.)

1885. G. H. FOWLER:

The anatomy of the Madreporaria, I. (Quart. Journ. Micr. Sci. (N. S.), vol. xxv., p. 577, pls. xl.-xlii.)

1885. A. C. HADDON AND G. Y. DIXON:

The structure and habits of *Peachia hastata* (Gosse). (Proc. Roy. Dub. Soc. (N. S.), vol. iv., p. 399.)

1885. A. S. PENNINGTON:

British Zoophytes.

1885. A. E. VERRILL:

Results of the Explorations made by the steamer "Albatross" off the northern coast of the United States. (Rep. U. S. Fish. Com. for 1883—Anthozoa, pp. 508–517; Actiniaria, pp. 534, 535; pls. v.-viii., xliv.)

1886. G. Y. DIXON:

Notes on two Irish specimens of *Edwardsia timida* (Quatrefages). (Proc. Roy. Dub. Soc. (N.S.), vol. v., p. 100, pl. vi.)

1886. A. C. HADDON:

Preliminary Report on the Fauna of Dublin Bay. (Proc. Roy. Irish Acad., ser. II., vol. iv., Science, p. 523.)

Note on *Halcampa chrysanthellum*, Peach. (Proc. Roy. Dub. Soc. (N.S.), vol. v., p. 1.)

First Report on the Marine Fauna of the south-west of Ireland. (Proc. Roy. Irish. Acad., ser. II., vol. iv., Science, pp. 599–638.)

1886. J. J. QUELCH:

Report on the Reef-Corals, collected by H. M. S. "Challenger." ("Challenger" Reports, vol. xvi.)

1887. G. C. BOURNE:

The Anatomy of the Madreporarian Coral, Fungia. Quart. Journ. Micr. Sci. (N. S.), vol. xxvii., p. 293, pls. xxiii.–xxv.)

1887. A. C. HADDON:

Note on arrangement of the Mesenteries in the parasitic larva of *Halcampa chrysanthellum* (Peach). (Proc. Roy. Dubl. Soc. (N. S.), vol. v., p. 473, pl. xi.)

1887. A. GÖETTE:

Entwicklungsgeschichte der *Aurelia aurita* und *Cotylorhiza tuberculata*, Hamburg. (Abhand. zur Entwick. der Thiere., 4 Heft.)

1887. W. C. M'INTOSH:

Notes from the St. Andrew's Marine Laboratory (under the Fishery Board of Scotland), No. vii., No. 3, On the Commensalistic Habits of the larval forms of Peachia. (Ann. Mag. Nat. Hist., ser. v., vol. xx., p. 101.)

1888. F. BLOCHMANN AND C. HILGER:

Ueber *Gonactinia prolifera*, Sars. Eine durch Quertheilung sich vermehrende Actinie. (Morph. Jahrb. xiii., p. 385, pls. xiv., xv.)

1888. A. F. DIXON:

On the arrangement of the Mesenteries in the genus Sagartia, Gosse. (Proc. Roy. Dub. Soc. (N. S., vol. vi., p. 136.)

1888. G. Y. DIXON:

Remarks on *Sagartia venusta* and *S. nivea.* (Proc. Roy. Dub. Soc. (N. S.), vol. vi., p. 111.)

1888. A. C. HADDON:

On two species of Actiniæ from the Mergui Archipelago. (Journ. Linnean Soc. Zool., vol. xxi., p. 247, pls. xix., xx.)

1888 A. A. C. HADDON:

Sixth Annual Report of the Fishery Board for Scotland, p. 281.

1888 B. A. C. HADDON:

Researches at the St. Andrew's Marine Laboratory (under the Fishery Board for Scotland)—On Larval Actiniæ parasitic on the Hydromedusæ at St. Andrew's. (Ann. Mag. Nat. Hist., ser. VI., vol. ii., p. 256.)

EXPLANATION OF PLATE XXXI.

PLATE XXXI.

Chitonactis marioni, n. sp.

Figure.

1. Side view of fully expanded animal on a spine of *Dorocidaris papillata.*
2. Side view of upper portion of the same during retraction.

Gephyra dohrnii, von Koch.

3. Group of cherry-coloured variety from locality near Great Skellig.
4. Groups of several specimens on tubes of *Tubularia indivisa.*
5. Side view of one of the same, and disc.

Actinauge richardi (Marion).

6. Group of three individuals, fully expanded; above, disc of another specimen with everted œsophagus; natural size.

EXPLANATION OF PLATE XXXII.

PLATE XXXII.

Paraphellia expansa, g. and sp. nn.

Figure.

1. Fully expanded disc, × 4 diam.
2. Side view of individual, with pedal disc retracted, × about 3 diam.
3. View of contracted specimen, with part of the arenaceous investment removed, × 2 diam.
4. View from above of fully expanded individual, divested of its covering of sand, × $2\frac{1}{2}$ diam.

Halcampa arenarea, Haddon.

5. Side view of extended animal, about 3 diam; also the same, greatly contracted; and the disc (diagrammatic), greatly enlarged.

" *Sagartia*," sp. (?)

6. Side view of fully extended animal attached to a Caryophyllia, × about $1\frac{1}{2}$ diam.

Chondractinia digitata (Müller).

7. Upper view of same, with the œsophagus puffed out.
8. Side view of a specimen drawn by Mr. P. H. Gosse, on June 11th, 1860, and presented to him by Mr. Stanger; natural size.
9. Side view of a specimen collected and drawn by Mr. Joshua Alder, Newcastle, 1856; natural size.
10. Upper view of same, with the œsophagus puffed out.

EXPLANATION OF PLATE XXXIII.

PLATE XXXIII.

Hormathia margaritæ, Gosse.

Figure.

1. Viewed from above, of preserved specimen, × 2 diam.
2. The same, from the side.

Gephyra dohrnii, von Koch.

3. (Cherry-coloured variety) (1886) portion of disk and tentacles, × 3 diam.
4. Side view of the same.

"*Sagartia*," sp. (?).

5. Preserved specimen on Caryophyllia; natural size.

Paraphellia expansa, Haddon.

6. Preserved specimen (1886); natural size.

Chitonactis marioni, n. sp.

7. Upper view of preserved specimen.
8. Same specimen, viewed from above, when alive.

Actinauge richardi (Marion).

9. Side view of preserved specimen, natural size.
10. Several tentacles of the various ranks, from the living animal (drawn by Mr. T. H. Thomas).

Chondractinia digitata (Müller).

11. Side view of a contracted spirit specimen, × 2 diam.
12. Side view of an uncontracted spirit specimen, × 2 diam.

Chondractinia nodosa (Fabricius).

13. Side view of a preserved specimen; natural size.

Halcampa arenarea, Haddon.

14. Preserved specimen (1886), × 2 diam.

Edwardsia carnea, Gosse.

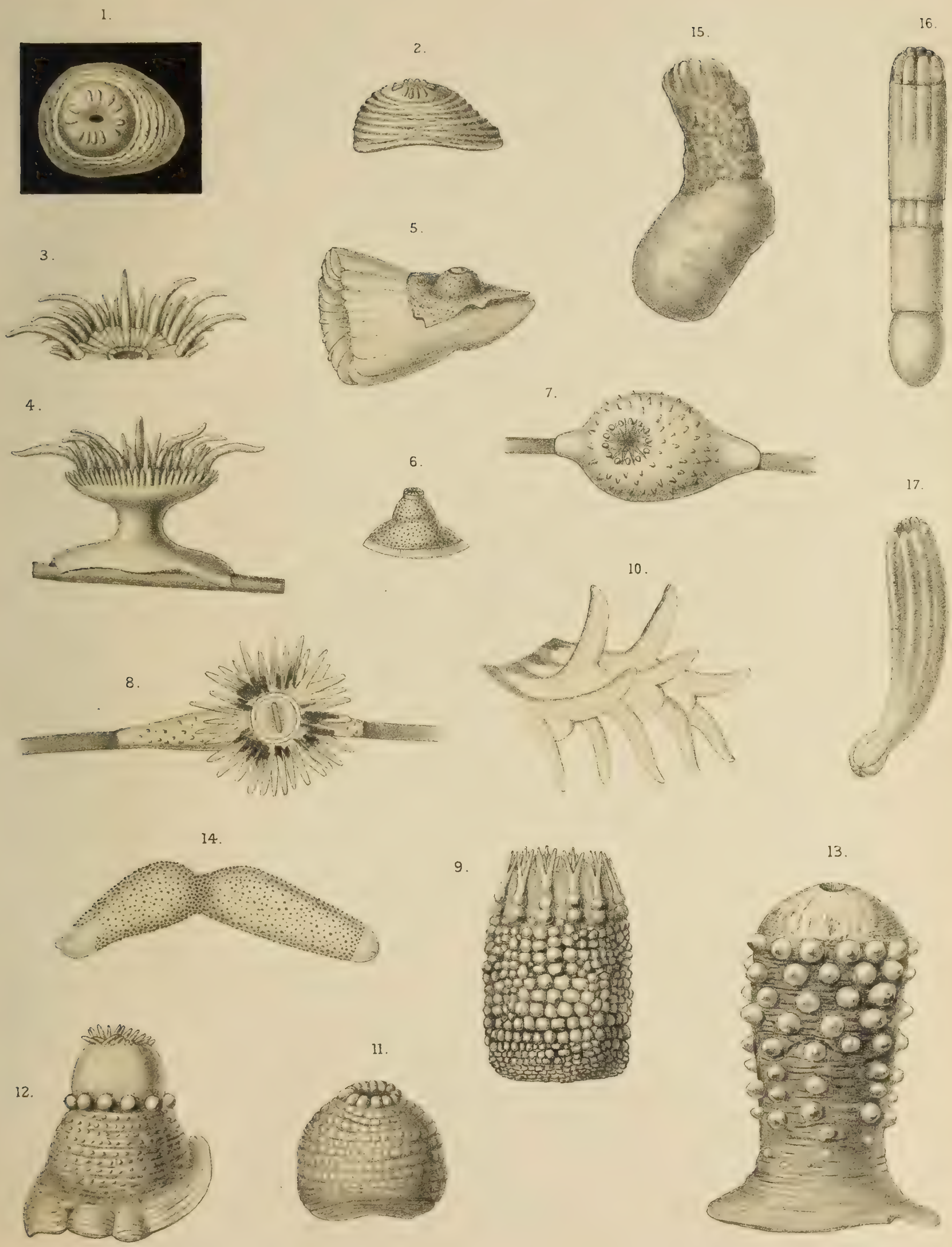
15. Preserved specimen, × 14 diam.

Edwardsia tecta, n. sp.

16. Preserved specimen, × 5 diam.

Edwardsia beautempsii, Quatrefages.

17. Living animal, contracted, × about 2 diam.



A C Haddon del ad nat.

EXPLANATION OF PLATE XXXIV.

PLATE XXXIV.

LETTERING ADOPTED IN ALL THE FIGURES.

a., . . .	acontia.
ax. t., . .	axial tentacle.
c. m., . .	circular muscle.
c. m. en., .	circular muscles of endoderm.
cu., . . .	cuticle.
d., . . .	directive mesenteries.
ec., . . .	ectoderm.
en., . . .	endoderm.
g. s., . .	grains of sand.
l. ex., . .	lateral exocœle.
m., . . .	mesoglœa.
m. f., . .	mesenterial filament.
n., . . .	nucleus.
œs., . . .	œsophagus.
œs. gr., .	œsophageal groove.
ov., . . .	ovum.
p. d., . .	pedal disk.
p. m., . .	parietal muscle.
r. m., . .	retractor muscle.
sc., . . .	sucker.
s., . . .	sulcus.
s. en., . .	sulcar endocœle.
s. ex., . .	sulcar exocœle.
s. d., . .	sulcar directive mesentery.
s. l. en., .	sulco-lateral endocœle.
sl., . . .	sulculus.
sl. d., . .	sulcular directive mesentery.
sl. en., . .	sulcular endocœle.
sl. ex., . .	sulcular exocœle.
sl. l. en., .	sulculo-lateral endocœle.
s. l. m., .	sulco-lateral mesentery.
sl. l. m., .	sulculo-lateral mesentery.
sp., . . .	sperm-cell.
z., . . .	zooxanthellæ.

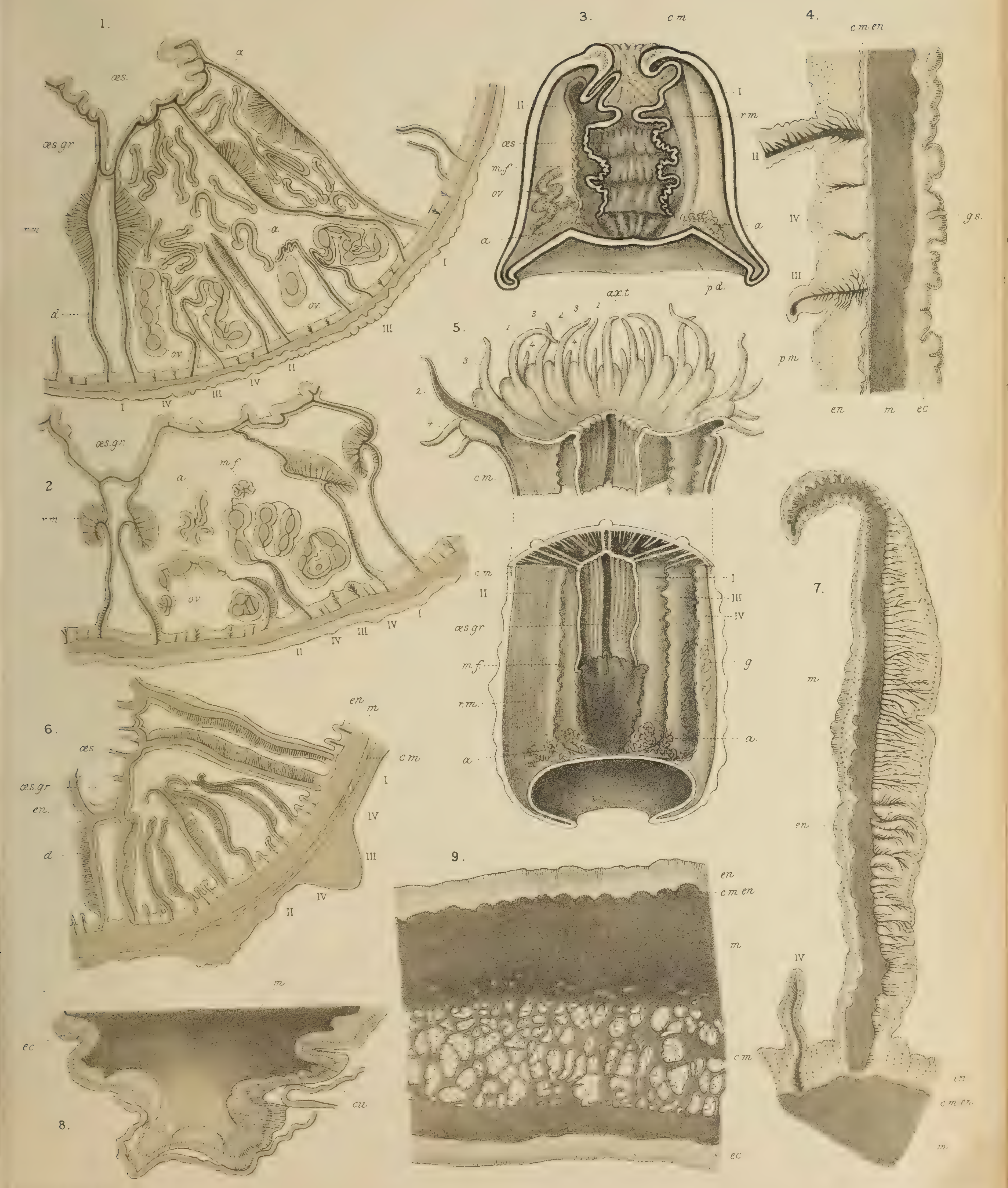
Paraphellia expansa, Haddon.

Figure.

1. Transverse section through middle of œsophageal region, $\frac{3}{a * 10}$.
2. Transverse section through inferior portion of œsophageal region, $\frac{3}{a * 1}$.
3. Vertical section of entire animal, $\times$ 4.
4. Transverse section of a portion of the body-wall, $\frac{2}{B}$.

Actinauge richardi (Marion).

5. Diagrammatic vertical section ; natural size.
6. Transverse section through œsophageal region, $\frac{3}{a * 5}$.
7. Transverse section of secondary mesentery, $\frac{2}{A}$.
8. Section of a tubercle, $\frac{3}{B}$.
9. Longitudinal section of a portion of the sphincter muscle.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VI.

ON THE FOSSIL FISH OF THE CRETACEOUS FORMATIONS OF SCANDINAVIA. By JAMES W. DAVIS, F.G.S., F.L.S., F.S.A., &c.

Plates XXXVIII to XLVI.

[Read April 16, 1890.]

[COMMUNICATED BY PROFESSOR E. P. WRIGHT, M.D.]

I.—INTRODUCTION.

During the year 1889 I had the pleasure, accompanied by my friend Mr. A. Smith Woodward, to visit some of the principal Museums in Sweden and Denmark, and to become personally known to those who were in charge of them. The collection of fish-remains from the chalk of South Sweden have received little attention since the time of S. Nillson, who first discovered fish remains in the Swedish chalk, and who described a few teeth in his work on the "Petrificata Suecana, formationis Cretaceæ," published in 1827. Eleven years afterwards W. Hissinger copied the plates of Nillson into his "Lethea Suecica seu Petrificata Sueciæ," but does not appear to have advanced beyond his predecessor. Since that time the number of examples of fossil fishes has largely increased, and the collections are now of great interest. The present memoir is due mainly to the suggestion of Dr. Bernard Lundgren, that the enlarged collections needed, and were worthy of, renewed study; and his offer, coupled with a subsequent one by Dr. G. Lindström, to allow the specimens to be sent to England for this purpose, was a sufficient inducement to me to accept it. An application to Dr. C. Lütken for the collection at Copenhagen was also readily granted, and others followed.

I have unfeigned pleasure in expressing my great indebtedness to Dr. G. Lindström, Keeper of Palæontology, National Museum, Stockholm; to Dr. Bernard Lundgren of the University of Lund; to Professor O. Torrell, Director of the Geological Survey of Sweden; to Dr. C. Lütken, Professor of Zoology at the University of Copenhagen; to Dr. F. Johnstrup, Director of the University Mineralogical and Geological Museum at Copenhagen, and to others, for their great courtesy and kindness in unreservedly placing the collections in their charge at my disposal, and so affording me the best opportunities possible to identify and record the occurrence of the fish remains which have been found in the chalk of Scandinavia. Dr. Lütken has kindly furnished me with particulars of his own

unpublished observations on the selachian teeth found in the white chalk of Faxe and Saltholm. The opinions of an authority of so high eminence have been very valuable. The collection from the University Zoological Museum at Copenhagen contains many specimens from the original museum formed by the late King Christian VIII. I am also indebted to Dr. Johnstrup for stratigraphical information respecting the localities in Denmark. Dr. Bernard Lundgren has furnished me with a table of formations, showing also the districts in which the localities occur from which fish remains have been obtained; and a published list of the fossil fauna of Sweden. And to Dr. Lindström I am under obligation for a variety of information not easily enumerated.

Dr. Henry Woodward, keeper of the geological collections at the British Museum, has, with his usual kindness, afforded me every opportunity to compare and study the specimens under his charge with the Scandinavian ones; and to Mr. A. Smith Woodward I am indebted for suggestions and information bearing on the subject of this memoir, and for the uniform courtesy and kindness with which he has given me advice and assistance both in and out of the Museum.

The ichthyic fauna of the Swedish chalk offers several points of considerable interest. It has shown, generally, a closer relationship to the cretaceous fauna of the North of Europe, as represented in the English and French chalk, than to the more highly specialized fauna of Asia Minor; but it does not afford representatives of several of the Physostomous Teleosteans such as Ichthyodectes, Protosphyræna, and Pachyrhizodus, which occur in the English chalk, and have been found in the Upper Cretaceous rocks of North America. A few teeth occur in the Swedish chalk which are referred to Enchodus. Examples of a large species of Dercetis occur, and some fragmentary remains which are probably Clupean. The highly specialized forms, such as Cheirothrix, Rhinellus, Spaniodon, Eurygnathus, and Eurypholis, found in the Lebanon chalk, do not occur in the chalk of Sweden. Amongst the Acanthopterygian Teleosteans the most important are the remains of Beryx and Hoplopteryx. These genera are represented in both the English and Lebanon chalk.

The great majority of the fish remains are Selachian, and comprise no fewer than twenty-four species. Three species, viz. *Carcharodon rondeletii* (M. & H.), *Otodus obliquus* (Ag.), and *Odontaspis acutissimus* (Ag.), are usually regarded and known as indicating a tertiary fauna; but in the Scandinavian chalk they have been found in association with many undoubted Cretaceous forms in the Faxe limestone or chalk, and so appear to prove that these species were in existence before the advent of the deposition of the Tertiary strata. The Tectospondylic sharks* are represented by two species of Phychodus and indefinable teeth of

* C. Hassè, Das Natürliche System der Elasmobranchier, 1879–82.

Myliobatis. The Asterospondylic sharks occur in very large numbers, and represent several genera. Beautifully preserved specimens of Notidanus, Scapanorhynchus (Rhinognathus), Odontaspis, Oxyrhina, Otodus, Lamna, and Corax are abundant, and have a wide vertical range. The teeth here described as *Oxyrhina lundgreni* possess peculiarities which, in some respects, dissociate them from Oxyrhina, and it may be found necessary to form them into a new genus. The character and extent of the Selachian fauna indicates conditions very similar to those accompanying the deposition of the English and French chalk and that of Central Europe generally, whilst it affords comparatively little data for comparison with that of Lebanon. The occurrence of numerous teeth of Scapanorhynchus in the Swedish area is worthy of note, but the fish are not found preserved bodily as they are in the Lebanon chalk.

The classification adopted is based, as far as possible, on that of the recently-published "Catalogue of the Fossil Fishes in the British Museum (Natural History), Part I.," by Mr. A. Smith Woodward. Whilst recognising the great merits of this work, and the painstaking care with which it has been compiled and arranged, it cannot be denied that there are some portions of the re-arranged classification which are open to doubt; and, possibly, to no group of fossil fishes does this apply more forcibly than to the Lamnidæ. I propose, therefore, to briefly review the most salient characteristics of the genera composing the Lamnidæ, especially those found in the chalk of Scandinavia, and drawing such deductions therefrom as appear to me most reasonable.

The following genera are included in the family Lamnidæ:—

Sphenodus, Agass. (Orthacodus, Smith Woodw.).
Alopecias, M. and H.
Cetorhinus, de Blainv. (Selache, Cuv., Hassè).
Carcharodon, M. and H.
Corax, Agass.
Otodus, Agass.
Oxyrhina, Agass.
Lamna, Cuvier.
Odontaspis, Agass.
Scapanorhynchus, Smith Woodw.

Sphenodus comprises four or five species, of which only the teeth are known, characterised by a wide base, with a slender median crown. All the species are found in the Jurassic rocks of the Continent, but have not been found in England. The genus Alopecias is also restricted to the Continent, and is found in the Molasse of Baltringen and the Eocene strata of Prussia. Selache or Cetorhinus,

founded on teeth and vertebræ which resemble those of *Selache* (*Cetorhinus*) *maxima*, occurs in the Tertiary strata of Antwerp, Italy, and Germany. The genus Carcharodon was established by Müller and Henle, who separated the species of this genus from those of Carcharias.* The type of the new genus was *Carcharodon rondeletii*, Müll. and Henle. The latter authors still further distinguished the two genera by the microscopical examination of their teeth. Those of the genus Carcharias were found to be hollow, whilst those of Carcharodon were solid, like those of the genera constituting the Lamnidæ. The Carcharodon was therefore removed, and incorporated with the family of Lamnidæ. The type of the genus is the single existing species *C. rondeletii.* The teeth of this species attain a length of an inch and a-half, and the entire length of the fish approaches forty feet. The teeth of the Tertiary representative of the genus *C. megalodon* are four or five inches in length; and if the fish was proportionally large it must have been of extraordinary size. The teeth of *C. rondeletii* exhibit considerable variety of form, but are all triangular, with serrated margins, but without lateral cones or denticles. The teeth in front on each side the symphysis of the jaws are higher in the crown and narrower at the base than those located further back; the posterior teeth gradually diminish in size, and, at the same time, become very broad in comparison to the height. The teeth of the lower jaw are more lance-like than those of the upper one, which are more uniformly triangular, with straighter margins.

The second dorsal fin and the anal are small. The lower lobe of the caudal fin is well developed, with a keel along the side, and there is a pit at its root.

Agassiz, in addition to the species of Carcharodon found fossil, which closely resembled the existing one, included in the genus a number of others which were unlike the type in possessing well-developed lateral denticles on their anterior and posterior borders. Whilst recognising the irregularity in form,† it did not appear of sufficient importance to justify the establishment of a new genus. Other species, in addition to the lateral denticles, depart still further from the type, in having the anterior border very much arched. Such species are *Carcharodon leptodon*, *C. disauris*, *C. megalotis*, *C. heterodon*, *C. auriculatus*,‡ *C. toliapicus*,§ and others. Agassiz is more specific in the statement of his opinion with respect to these species, that they ought, at some time, to be isolated with others to form a genus apart. He is confirmed in this opinion by the fact that in the living species the tendency of the teeth to assume an arched form is scarcely perceptible, whilst it is constantly seen in some other genera of Lamnidæ, and in true examples of Carcharias.

* Syst. beschrieb. Plagiostom, p. 70. 1841.

† Rech. Poiss. Foss., vol. iii., p. 246.

‡ Agassiz, Poiss. Foss., vol. vii., pl. xxviii.

§ *Op. cit.*, pl. xxx. *a*, fig. 14.

Corax is known only by the teeth. They are sufficiently distinctive in form and of world-wide distribution. They are distinguished from the teeth of the existing Carcharias and Galeus, to which they bear considerable resemblance, by having no central cavity. The teeth of the existing fishes are hollow.

Teeth of Otodus are only known in a fossil state. The genus was instituted by Agassiz for teeth which exhibited forms intermediate between Carcharodon on the one side, and Oxyrhina and Lamna on the other. They agree with the genus Lamna in possessing lateral denticles; but whilst those of Lamna and Odontaspis are cylindrical and sharply pointed, those of Otodus are larger, flat, and blunt. The same characters may also be said to distinguish the crown of each respectively. The root of Otodus is very large and thick; but it has not the extended horn-like projections which characterize Lamna.* From Oxyrhina this genus is distinguished by the presence of the lateral denticles, and from Carcharodon it is separated by the absence of the serrated margins which characterize the former. Agassiz regards this character as of great importance, and though it may be of doubtful value in some species placed on the confines of the genera, he regards it as not less decisive in the greater number. He says, however (p. 266): "Il en est de ceci comme de toutes nos diagnoses; elles ne sont vraies que dans certaines limites, et c'est a la perspicacité du naturaliste à reconnaitre et à sentir où ces limites se trouvent." The microscopical structure of the teeth is solid and massive, as in Carcharodon and the true Lamna. The genus appears first in the Cretaceous rocks, was abundant in the Tertiaries, and died out before the existing period.

The genus Oxyrhina includes one or two existing species. The type of the genus, and the one best known, is *Oxyrhina spallanzani* (*Lamna oxyrhina*, Cuv. and Val.). The teeth are completely free from lateral denticles, and the margins are smooth. The crown of the tooth is very similar in form to that of Otodus; and imperfectly-preserved specimens of Otodus, from which the base has been broken so as to detach the lateral denticles, can with difficulty be distinguished from Oxyrhina. The fossil teeth attain a considerable size; they conform generally with the ordinary arrangement of the teeth in sharks; those situated on the anterior part of the jaws are more lanceolate and acutely pointed than those occupying a median position, whilst the posterior teeth are smaller, triangular, and much compressed.

The genus Lamna was originally founded by Cuvier,† and embraced a variety of fishes which have since been taken as the types of other genera, amongst them Otodus, Carcharodon, and Oxyrhina, characterized by the form of the teeth. Of the existing sharks, *Lamna cornubica*, Cuv., may be taken as the type of the genus.

* Agass. Poiss. Foss., vol. iii., p. 266. † Règne Ânimal, vol. ii., p. 126. 1827.

Müller and Henle, amongst other characters of the genus, give:* "the second dorsal and anal small of equal dimensions, opposite; pit at base of caudal distinct, a keel along each side of the tail." These characters apply equally to Oxyrhina and Carcharodon; Odontaspis is distinguished by the second dorsal and anal fins being large; having no pit at the root of the tail, and the absence of keels along the lateral surface. In all three genera the branchial arches are large and situated in front of the pectoral fin. All the characters on which Müller and Henle based their classification are external, and pertaining to parts of the body which are not usually found in a fossil state, and the palæontologist, as Agassiz points out,† sees with regret that no account whatever is taken of the skeleton or the dentition; and it is a remarkable coincidence, that the teeth which present the nearest resemblance, viz. those of Lamna and Odontaspis, should be distinctly removed by the external form of the caudal fin, and by the position and size of the dorsal and anal fins to separate genera; whilst Cetorhinus, Blain. (Selache, Cuv.), Oxyrhina, Agass., and Carcharodon, Müller and Henle, which have teeth of such great dissimilarity to Lamna, are grouped in the same family in close relationship with that genus.

The teeth of *Lamna cornubica*, Cuv., are more or less varied in form in different parts of the jaws; they may be described as possessing a high, median, cone-shaped crown, flat, and compressed antero-posteriorly, with smooth margins; a single lateral denticle exists on each side of the median cone. The median cone approaches to that of Otodus in form on the one side, but the lateral cones are smaller and more acuminate; and on the other, it possesses much resemblance to some of the teeth of Odontaspis. It is principally distinguished by the cylindrical, and often twisted form of Odontaspis, which has also longer and more pointed lateral denticles. In Lamna the lateral denticles do not number more than one on each side, but in Odontaspis there are frequently two, and occasionally three on each side. The number is, however, inconstant, and even the teeth of the same fish sometimes are variable. Agassiz very forcibly remarks that the variation observed in the number of the lateral denticles is not calculated to inspire a great amount of confidence in their value for determining genera.

The teeth of Lamna are readily distinguished from those of Oxyrhina, if the base of the tooth and the root are well preserved, because Oxyrhina has no lateral denticles; from those of Otodus they are less readily distinguished, and some intermediate species appear to bridge over the limits between the two genera, such for example as *Otodus appendiculatus*, one of the most common forms, which can scarcely be distinguished from some of the Lamna.

Some of the characters of Odontaspis have already been enumerated. The

* Systematische Beschreibung der Plagiostomen, p. 66.

† Poiss. Foss., vol. iii., p. 287.

genus is represented by species still existing. In one of them, *Odontaspis ferox*, Agass., all the teeth except those situated most posteriorly, have a high, narrow, pointed crown, on each side of which are two, sometimes three, rounded and acuminate denticles. Both these and the median cone are more or less cylindrical, and usually exhibit a sygmoidal curvature. The teeth of both the upper and lower jaw are similar in form; on each side of the symphysis there is a small pointed tooth, succeeded by much larger ones, narrow at the base as compared with the height of the crown. In the upper jaw between the second and third large tooth, the fourth and succeeding ones from the symphysis, there are four teeth, very small, about one-third the height of the large front teeth. After these are larger ones, broader at the base, all with acuminate crowns, and diminishing in size backwards. In the lower jaw the intermediate small teeth do not occur, but the teeth gradually diminish in height and size backwards. All are possessed of two lateral denticles on each margin of the teeth. Agassiz* did not consider that the teeth of Odontaspis were separated with sufficient distinctness from Lamna to warrant him in forming a new genus; but the teeth found fossil which approached the living Odontaspis, he indicated by placing the word in a parenthesis.

Another genus of the Lamnidæ occurs in the chalk of Mount Lebanon, and was described by the writer† as Rhinognathus. It forms one of a very few instances in which the body of a Lamnoid fish with teeth in the natural position have been found fossil. It is distinguished from existing genera by the length of the anal fin. The body is long, and the snout much elongated, and more or less spatulate. The teeth are long and accuminate, with a pair of small lateral denticles in the anterior part of the jaws, broader and shorter behind. The teeth are not readily distinguishable from those of Odontaspis; and the broader ones are not unlike some of the species of Lamna. Mr. A. Smith Woodward‡ has pointed out that the generic name Rhinognathus was pre-occupied by Fairmaire in 1873, and has suggested Scapanorhynchus in its stead.§

In addition to the species from Lebanon, Mr. Woodward has included under this genus several species described by authors as Lamna and Odontaspis.

Dr. H. E. Sauvage‖ in 1872 described a number of fish remains from the Cretaceous rocks of Sarthe, and amongst others, species of the genera Oxyrhina, Otodus, Lamna, and Odontaspis. Agreeing with Agassiz in the diagnosis of

* Poiss. Foss., vol. iii., p. 288.

† James W. Davis On the Fossil Fishes of the Chalk of Mt. Lebanon, in Trans. Roy. Dub. Soc., N.S., 1887, part v., vol. iii., p. 480.

‡ Catalogue Foss. Fishes in the Brit. Mus., 1889, part i., p. 351.

§ The inference drawn by Mr. Woodward that this genus was considered as one of the Spinacidæ is incorrect. The omission of a line after the description of the preceding species may have led to the error.

‖ Rech. sur les Poiss. Foss. du Terrain Crétacé de la Sarthe, in Bibl. École Hautes Études, vol. v., art. 9, p. 20.

Oxyrhina, he observes that in the young stages of Lamna the teeth are without lateral denticles, and that these only develope later. Of the genus Otodus, he remarks that it is closely allied with Lamna, from which it only differs in the greater development of the lateral denticles, their broader and less slender form. The teeth of Otodus, whilst having the form of those of Carcharodon, are not serrated on the margins, but in the opinion of M. Sauvage the three genera named are closely related. He quotes an observation of M. Pictet, that these teeth in many instances vary more from different parts of the same mouth than their homologues in another species, and that this variation renders the difficulty of the interpretation of their exact specific characters very great. This observation applies with considerable force to the genera Lamna and Odontaspis, the teeth of which closely resemble each other; but the fishes still existing enable the naturalist to study and compare them, and their relationship is far more distant than some of the other genera whose teeth have less resemblance. Palæontologically it is very difficult to separate the two genera, which are quite distinct in living examples.

In the year 1854 Valerian Kiprijanoff described a number of Selachian teeth from the Cenomanian ferruginous sandstones of the governments of Kursk and Orel, in Russia.* The characteristics of the teeth of the genera before named, as defined by Agassiz, are cited; the difficulty of determining fragmentary examples is stated to be almost insurmountable, and the microscopical examination of the structure of the crown of Otodus, Lamna, and Oxyrhina is found to afford no definite characteristics. The description of several species of Otodus, led the author to seek the relationship of the genus with other associated forms, and he expressed the opinion founded on his investigation, that the broad teeth approach most nearly to Carcharodon, whilst towards the opposite extreme their similarity to the teeth of Lamna stand out clearly. Specimens without lateral denticles are indistinguishable from the teeth of Oxyrhina. Kiprijanoff states that in young examples the teeth of Odontaspis possess lateral denticles at an earlier stage than do those of Lamna; and he regrets that an example of the jaw of Otodus has not been found, so that some information as to the arrangement of the teeth *in situ* might be obtained.

Professor Zittel† accepts the general definition of the genera of the Lamnidæ, and cites the opinion of C. Hassè ‡ that the Lamnidæ have developed from the Scylliolamnidæ, with which they are nearly connected, especially through the

* Fisch-Ueberreste im Kursksche eisenhaltigen Sandsteine by Valerian Kiprijanoff; Bull. de la Soc. Imperiale des Naturalistes de Moscou, 1854, vol. xxvii., p. 373.

† Handbuch der Palæontologie von Karl A. Zittel, band iii., p. 81. 1887.

‡ Das Natürliche system der Elasmobranchier von C. Hassè; 1879: *see* Stammtafel I.

genus Otodus; at the same time, regarding Otodus as a connecting link between the two families, he considers that it is so close to the typical Lamnidæ that it is difficult to draw a line to divide them.

Perhaps the most recent contribution to the subject is by A. Smith Woodward in the Catalogue of the Fossil Fishes in the British Museum.* The great bulk of the teeth of Lamna, previously described, are transferred to the genus Odontaspis, and those of Otodus to the genus Lamna; Otodus, except as a synonym, dropping out of the vocabulary. The Lebanon genus Rhinognathus renamed Scaphanorhynchus is accepted, and included with it are some of the species of Lamna (Odontaspis) described by Agassiz. Oxyrhina is retained without alteration, and the teeth are defined as without denticles, but it is stated on another page that some of the teeth of this genus have minute denticles. Woodward is of opinion that "although only differing from Lamna in the prevailing absence of lateral denticles in the teeth, it is convenient from a palæontological point of view to retain Oxyrhina as a distinct genus, more especially as several forms of these teeth bear specific names identical with those referable to Lamna proper." *Lamna acuminata*, Agassiz †, is included as a synonym of *Oxyrhina mantelli*, Agass., apparently on the authority of Sauvage, but that author ‡ is doubtful whether the teeth, figs. 55, 56, 57, are referable to *L. acuminata*, but has no doubt about fig. 54, which he accepts as the type of the species. If this view be correct, the tooth represented by fig. 54, Woodward, to be consistent, should have included in his genus Odontaspis; the presence of well-formed lateral denticles clearly indicates that genus. Carcharodon remains unchanged as a genus, but the species are redistributed.

Sauvage § in the memoir already cited, points out that M. Reuss ‖ has given a figure of a tooth with feeble denticles, which that author considered to be an example of *Oxyrhina mantelli*, Ag. Sauvage, however, gives reasons for believing that the determination of Reuss is erroneous, and that the tooth ought be classed with *Otodus oxyrhinoides*, Sauvage. It is probable that an equally careful examination of other examples of teeth which possess evidence of lateral denticles, would prove that they ought not to be considered as pertaining to Oxyrhina, although they may have been found associated with undoubted teeth of that genus, and described with them.

Having thus briefly indicated the genera included in the family of the Lamnidæ, it is proposed to sum up the evidence, and if possible arrive at some reasonable view for the classification of a group of fish-remains which are perhaps as per-

* Part i., p. 349, *et seq.*

† Poiss. Foss., vol. iii., p. 292, pl. xxxvii.*a*, fig. 54 (? *non* figs. 55, 57).

‡ Poiss. Foss. de la Sarthe, p. 35.

§ *Op. cit.*, p. 25.

‖ Verst. der Böhm. Kreid., 1845, pl. iii., fig. 6.

plexing as any in the whole range of palæontological science. The most profitable method of investigating fossil remains is by comparison with existing forms, and it is fortunate that all the genera are not yet extinct; and though the fossil forms far outnumber the existing ones, there are still examples of Carcharodon, Lamna, Oxyrhina, and Odontaspis. As already observed the characters of the first three existing genera as defined by Müller and Henle, having reference to the size, form, and position of the fins and tail, are identical, and so far as those tests are concerned do not indicate any generic differences. Odontaspis, on the other hand, differs from those named, in the form and position of the fins and tail, to such an extent as to induce Sauvage to place it as a separate *family;* whilst, judging from the teeth alone, Agassiz and others have regarded them as at most a sub-genus of Lamna. After carefully considering the divisions of the Lamnidæ attempted by Müller and Henle, Agassiz expresses the opinion that they may be tangible enough, and very serviceable in existing forms, when the whole of the structure of the fish may be studied, but of little use when considering and attempting to decipher a mass of detached fragments, in nearly all cases consisting of isolated teeth or vertebræ.

The Cretaceous fish-remains, Agassiz says, are characterized by a large number of new types which have not existed at an earlier period. The group of teeth with crenulated margins appears for the first time; and amongst the smooth teeth are several types equally new, such as Otodus, Oxyrhina, and the subulate Lamna, or Odontaspis. The greatest difficulty consists in distinguishing between Otodus and Oxyrhina; and between Otodus and certain forms of Lamna; also, it is necessary in certain cases to renounce the hope of rigorously determining fragments of teeth deprived of their roots. The difficulties which encompassed Agassiz have increased since he wrote; and the discovery of numerous forms in all parts of the world, and the accumulation of large collections of fish-remains in public and private museums, have only served to produce a still more complicated result and render still more difficult a satisfactory system of classification.

The existing Lamnidæ as represented in Carcharodon and Oxyrhina indicate two distinct forms of dentition both free from lateral denticles, the former with serrated anterior and posterior margins, and the latter with those margins devoid of serrations. These are abundant in the Tertiary strata, and Oxyrhina also in the Cretaceous.

Agassiz held the opinion that the serrated margin of the teeth was of generic importance, and this led him to include a number of forms with well-developed lateral denticles in the genus Carcharodon because they had serrated margins. The question immediately arises whether the serrated margin, or the presence of secondary cones is of greater generic importance. So far as the evidence of the existing species goes, there is no trace of lateral cones or denticles, and if

C. rondeletii be taken as the type, then it becomes anomalous to include in the genus such forms as *Carcharodon heterodon*, Ag., *C. megalotis*, Ag., *C. auriculatus*, Ag., *C. angustidens*, Ag., and others. In form and size they approach very nearly to some of the larger species of Otodus, such as *O. obliquus*, Ag., and if the margins of the latter were serrated would be indistinguishable from it.

Noetling has already suggested that Otodus should be joined to Carcharodon; but it appears much more reasonable, either that the forms associated with Carcharodon which possess lateral denticles should be considered as species of Otodus, or regarded as a separate genus.

Having regard to the remaining genera Lamna, Otodus, and Odontaspis, existing species of the first and last still survive; but unfortunately, hitherto, no specimen of a living Otodus has been discovered, but so many wonderful types have been found by deep sea dredging and more careful search, during the past few years, that it may not be impossible that still others may be brought to light. At any rate, until more reliable information is accessible, it may best serve the purpose of the palæontologist to regard the dismembered fragments simply as "forms" exhibiting certain tendencies of a more or less definite character. Sufficient has already been advanced to show that any lines of absolute demarcation into genera, it might almost be said species, is impossible; and the researches of every fresh student may lead to new opinions formulated in new varieties of nomenclature. Already the subject is almost hopelessly confounded; the transposition of species is bewildering; and after all there is no firm basis on which to build up a natural classification.

One of the principal difficulties appears to be, that it should be desired to make an extremely large series of fossils, representing an enormous development of the Selachians, fit to a minimized series of living representatives which are rapidly dying out; and that sufficient credit is not given to the variety and number of the species which obtained during the ascendancy of the family. Accepting this view it may be advisable to regard the teeth, as already suggested, as "forms" representing members of the family, and classify them accordingly; and it scarcely seems necessary to suggest that the successive redistribution of species amongst existing, or newly devised genera, is to be deprecated. The genera as defined by Agassiz embrace already a wide range of species, and have, hitherto, proved adequate. They are universally known and accepted, and have tolerably well-defined limits. Taking as types, *Otodus obliquus*, and the existing species *Lamna cornubica*, and *Odontaspis ferox*, the palæontologist will be able to group the ever-varying fossil forms around these centres, and though they may possess characters expressing relationship with more than one species, succeeding discoveries may show that these only express the connecting links of an unbroken line of evolutional development.

II.—CLASSIFIED DESCRIPTION OF THE FOSSIL FISH.

Class.—PISCES.

Sub-Class.—ELASMOBRANCHII.

Order.—SELACHII.

Sub-Order.—TECTOSPONDYLI.

Family.—**MYLIOBATIDÆ.**

Genus. **Myliobatis.** CUVIER. "Règne Animal," vol. ii., p. 137. 1817.

Head free from the disk; so-called cephalic fin single. Teeth large, flat, hexangular, tesselated, arranged in seven antero-posterior series. The dentition of the upper jaw strongly arched antero-posteriorly, that of the lower jaw quite flat. Dental crown smooth, or slightly striated; attached surface of root longitudinally rigid and grooved. Except in very young individuals, in which the teeth are all approximately of equal size, the median row is relatively very broad, while the teeth of the three lateral series on each side are rarely broader than long. Tail with a dorsal fin near its root, generally with a posteriorly-situated barbed spine.

Myliobatis, sp. ?

Fragments of the teeth of this genus occur in the collection of the University of Lund. The coronal surface is smooth, and presents a somewhat reticulated appearance, due to the attrition of the upper extremities of the descending nutritive canals. The root, composed of coarse lamellæ, is smaller than the crown, and is separated from it by a concave depression of the posterior surface, the root projecting beyond the crown; on the anterior surface the reverse happens, the surface of the crown extending beyond the root.

The specimens are fragmentary, and of too indefinite a character to determine the species.

Ex coll.—Geological collection, University of Lund.

Genus. **Ptychodus.** AGASSIZ. "Poiss. Foss.," vol. iii., p. 150. 1839.

Syn.—Aulodus, F. Dixon, "Foss. Sussex.," p. 366. 1850.

Teeth quadrate in form, with elevated crown, somewhat overhanging, and sharply separated from the root by a constriction. The crown is enamelled, and ornamented with large transverse or radiating ridges, surrounded by a more finely-marked marginal area of greater or less extent. The surface of attachment of root is smooth. In one jaw, presumably the lower, the median series of teeth is the largest, and the lateral rows are arranged symmetrically, diminishing in size to the left and right. In the opposing dentition the median series is very small, and the first lateral row on each side large, with the outer lateral series successively diminishing in size. The vertebræ are very deep compared with their length, complete, and apparently cyclospondylic in structure.

The well-known teeth of Ptychodus were supposed by Mantell * to have formed the dental armature of a teleostean fish nearly allied with the Diodon. The observations of Agassiz,† and the microscopical investigations of Owen,‡ led to the conclusion that the arrangement of the teeth of Ptychodus closely resembled that of the Cestraciont sharks. The absence of any specimens showing the teeth in actual position has led to a general acceptance of the view enunciated by Agassiz. More recently, Cope,§ in America, and Smith Woodward,‖ in this country, have been able, by the discovery of more perfect specimens, to arrive at conclusions of great importance. Cope demonstrated that the spinous processes supposed to have been the dorsal spines of Ptychodus were the fin-rays of a Teleostean fish; and Woodward has shown that the teeth have no agreement with the dental arrangement in the Cestraciont shark, but that the dentition is that of a true ray. The arrangement of the teeth is in parallel rows, crossing the rami at right angles. There is a median row in each jaw, and on either side of it there are series placed symmetrically right and left. In the upper jaw the median teeth are small; the largest are placed in the first lateral series, from which there is a gradual diminution in size outwards. In the lower jaw the median teeth form

* Fossils of the South Downs, p. 231. 1822.

† Recherches sur les Poissons Fossiles, vol. iii., pp. 56–59, 150–158, 162.

‡ On the Structure of Teeth, Brit. Assoc. Rep., 1838, Trans. Sect., p. 140; and Odontography, pp. 57–59, pls. XVIII., XIX.

§ Vertebrata of the Cretaceous Formations of the West (U. S. Geol. Surv. Terr., 1875), p. 244 A–F.

‖ Quart. Journ. Geol. Soc., vol. xliii., pp. 123–130., pl. X.

the largest row, fitting into the central groove of the opposing dentition, and on either side the teeth of the lateral series become successively smaller.*

Professor E. D. Cope † has discovered an interesting series of teeth in the uppermost Cretaceous beds of Maria Farinha, which apparently occupies a position intermediate between Ptychodus and the living ray, Myliobatis, and which he has named Apocopodon. The teeth are covered with a thick layer of enamel, which is ridged antero-posteriorly. The median teeth are shorter than Myliobatis, and differ from both that genus and also Zygobatis in being exactly parallelogrammic in outline, the extremities being truncated instead of angulated, as in those genera. It may also be noted, that some of the Eocene Myliobatidæ possess teeth which approach more or less closely to the form of Ptychodus. A species described by Leidy ‡ from the phosphate beds of North Carolina as *Myliobatis jugosus*, may be taken as an illustration. Professor W. Dames § has also described detached teeth from the Tuffkreide of Maastricht which appear to possess characteristics indicating an intermediate position between Ptychodus and Myliobatis, and so forming a sort of connecting link. The teeth are named by Dames *Rhombodus binkhorsti.* The occurrence of these intermediate forms in various and widely separated parts of the world may indicate that the Ptychodonts were the antecedent types of the Myliobatidæ; and they certainly assist in confirming the results of Smith Woodward's researches.

Ptychodus decurrens, Agassiz.

(Pl. xxxviii., figs. 1, 2.)

Dens piscis ostracionis. Bruckmann, F. E., 1752. "Acta. Phys. Med.," vol. ix., p. 116, pl. v., fig. 4.
Palate of unknown fish. Parkinson, J., 1811. "Organic Remains," vol. iii., pl. xviii., fig. 12.
Ptychodus decurrens. Agassiz, L., 1839. "Poiss. Foss.," vol. iii., p. 154, pl. xxv. *b*, figs. 1, 2, 4, 6–8 (*non* 3, 5).
Ptychodus decurrens. Owen, R., 1840–45. "Odontography," volume ii., pls. vi.–xii., xix.

* A. S. Woodward, Proceedings of the Geological Association, vol. x., p. 296. 1888.

† A contribution to the Vertebrate Palæontology of Brazil, in Proc. Amer. Phil. Soc., vol. xxiii., p. 2. 1886.

‡ J. Leidy, Journ. Acad. Nat. Sci. Philadelphia, ser. 2, vol. viii., p. 240, pl. xxxi., figs. 4, 5. 1877.

§ Sitzungsb. Ges. Naturf. Freunde, Berlin, pp. 1–3. 1881.

Ptychodus decurrens.	Pictet, F. J., 1845. "Paléontologie," vol. ii., p. 287.
Ptychodus decurrens.	Giebel, C. G., 1848. "Fauna der Vorwelt," p. 333.
Ptychodus decurrens.	Dixon, F., 1850. "Foss. Sussex," p. 362, pl. xxx., figs. 7, 8; pl. xxxi., fig. 1; pl. xxxii., fig. 5.
Ptychodus depressus.	Dixon, F., 1850. "Foss. Sussex," p. 363, pl. xxxi., fig. 9.
Ptychodus decurrens.	Gervais, P., 1852. "Zool. et Pal. Franç.," pl. lxxviii., fig. 5.
Ptychodus decurrens.	Kiprijanoff, V., 1852. "Bull. Soc. Imp. Nat. Moscou," vol. xxv., pt. ii., p. 490, pl. xiii., figs. 4,* 5.
Ptychodus decurrens.	Quenstedt, F. A., 1852. "Handb. Petrefakt.," p. 181, pl. xiii., fig. 59.
Ptychodus polygyrus.	Fischer, C. E., 1856. "Allgem. deutsche naturh. Zeit. Dresden," N. S., vol. ii., p. 140, figs. 31–33.
Ptychodus decurrens.	Sauvage, H. E., 1872. "Biblioth. Ecole Hautes Etudes," vol. v., art. 9, p. 18.
Ptychodus decurrens.	Geinitz, H. B., 1875. "Palæontog.," vol. xx., pt. i., p. 296, pl. lxiv., figs. 24, 25.
Ptychodus latissimus.	St. Zarecznego, 1878. "Sprawozdanie Komisyi Fizyjograf. Galicyi," vol. xii., p. 200, pl. viii., fig. 8.
Ptychodus decurrens.	Fritsch, A., 1878. "Reptil. u. Fische. böhm Kreideform.," p. 14, fig. 34.
Ptychodus decurrens.	Quenstedt, F. A., 1882. "Handb. Petrefakt.," 3rd ed., p. 281, woodcut, fig. 86, pl. xxi., figs. 63, 64.
Ptychodus decurrens.	Woodward, A. S., 1887. "Quart. Journ. Geol. Soc." vol. xliii., pp. 123–130, pl. x., figs. 1–10, 13.
Ptychodus decurrens.	Woodward, A. S., 1889. "Catal. Foss. Fishes Br. Mus.," p. 138.

Represented by teeth from the soft white chalk of Annetorp and Oretorp in the palæontological collection of the Riksmuseum at Stockholm. The larger tooth is probably from the first lateral series of the upper jaw;† it measures 0·02 m. across, and has a length antero-posteriorly of 0·017 m.; nine ridges are exposed, extending across the crown in nearly straight lines; on each side they bifurcate, and split up into a number of minute corrugations along the margins. The nine ridges occupy an area of the surface of 0·012 m., the remaining portion being covered with ramifying ridges increasing in number towards the margin. The crown of the tooth is slightly convex. The root is buried in matrix.

* A doubtful tooth, subsequently assigned to *P. oweni*, Kiprijanoff, *loc. cit.*, pt. ii., p. 2. 1881.

† See Woodward's figures in Quart. Journ. Geol. Soc., vol, xliii., pl. x., fig. 4.

The second specimen is from Oretorp; less than half the size of the one described. The surface of the crown is flat, and exhibits a slight obliquity. Its location appears to have been in one of the series near the lateral extremity of the upper jaw. There are six transverse ridges, in form more or less semicircular, which occupy nearly the whole of the crown. The space occupied by the marginal corrugations is not large, but the characteristic folds extending from the central portion to the periphery are quite distinct.

Formation and Locality.—Etage Danien; Annetorp, District of Malmä, Oretorp.

Ex coll.—Riksmuseum, Stockholm.

Ptychodus mammillaris, AGASSIZ.

(Pl. XXXVIII., fig. 3.)

Tooth allied to Diodon.	MANTELL, G. A., 1822. "Foss. S. Down," p. 231, pl. XXXII., figs. 17, 18, 20, 21, 27, 29.
Ptychodus mammillaris.	AGASSIZ, L., 1839. "Poiss. Foss.," vol. iii., p. 151, pl. xxv. *b*, figs. 12–20 (? fig. 11).
Ptychodus decurrens.	AGASSIZ, L., 1839. *Tom. cit.*, p. 154, pl. xxv. *b*, figs. 3, 5.
Ptychodus altior.	AGASSIZ, L., 1839. *Tom. cit.*, p. 155, pl. xxv. *b*, figs. 9, 10.
Ptychodus mammillaris.	REUSS, A. E., 1845. "Verstein. böhm. Kreideform," pt. i., p. 2, pl. II., figs. 11–13.
Ptychodus mammillaris.	GIEBEL, C. G., 1848. "Fauna der Vorwelt," vol. i., p. 333.
Ptychodus mammillaris.	DIXON, F., 1850. "Foss. Sussex," p. 361, pl. XXX., fig. 6; pl. XXXI., fig. 4.
Ptychodus mammillaris.	GEINITZ, H. B., 1850. "Charact. Böhm-Sächsisch. Kreidegeb.," 2nd ed., p. 64, pl. XVII., fig. 7.
Ptychodus decurrens.	GEINITZ, H. B., 1850. *Op. cit.*, p. 64, pl. xvii., figs. 8–12.
Ptychodus mammillaris.	KIPRIJANOFF, V., 1852. "Bull. Soc. Imp. Nat. Moscou," vol. xxv., pt. ii., p. 487, pl. XII., fig. 3; pl. XIII., fig. 3.
Ptychodus mammillaris.	PICTET, F. J., 1854. "Palæont.," 2nd ed., vol. ii., p. 265, pl. XXXVIII., fig. 27.
Ptychodus mammillaris.	FISCHER, C. E., 1856. "Allgem. deutsch. naturh. Zeit. Dresden," N.S., vol. ii., p. 139, pl. II., fig. 34.

Ptychodus mammillaris. Roemer, F., 1870. "Geol. von Oberschlesien," p. 324, pl. xxxvi., fig. 8.

Ptychodus mammillaris. Sauvage, H. E., 1872. "Biblioth. Ecole Haute Etudes," vol. v., art. 9, p. 16, pl. ii., figs. 86–89.

Ptychodus mammillaris. Geinitz, H. B., 1875. "Palæontogr.," vol. xx., pt. i., p. 297, pl. lxiv, fig. 26; pt. ii., p. 213, pl. xl., figs. 23–29.

Ptychodus mammillaris. Fritsch, A., 1878. "Reptil. und Fische böhm Kreideform," p. 14, woodcut fig. 33.

Ptychodus mammillaris. St. Zarecznego, 1878. "Sprawozdanie Komisyi Fizyjograf. Galicyi," vol. xii., p. 201, pl. viii., fig. 9.

Ptychodus mammillaris. Quenstedt, F. A., 1885. "Handb. Petrefakt," 3rd ed., p. 282, pl. xxi., figs. 61, 62.

Ptychodus mammillaris. Woodward, A. S., 1889. "Catal. Foss. Fishes in Brit. Museum," pt. i., p. 133.

The occurrence of *Ptychodus mammillaris* is not common. The specimen figured is from the white chalk of Annetorp. It is very high in the crown, with ten or twelve transverse ridges extending across the somewhat narrow surface. The diameter of the base is 0·015 m., equal to the height of the crown. Below the coronal surface the sides are depressed, and covered with more or less concentric granulated striæ; still lower the sides again expand, and the base is prominent, and covered with fine vertical striations.

Formation and Locality.—Etage Danien: Annetorp, District of Malmä.

Ex coll.—Riksmuseum, Stockholm.

Sub-Order.—Asterospondyli.

Family.—NOTIDANIDÆ.

Genus. **Notidanus**. Cuvier.

Body moderately elongated; one dorsal fin opposite to the space between the ventral and anal fins; caudal fin large, without pit at the root; mouth inferior; gill-openings—six or seven—without flaps of skin; spiracles small, on the side of the neck. Notochord persistent. Principal teeth consisting of a series of compressed cusps, fixed upon a long base, the anterior cusp larger than the others, with or without small denticles at its base in front. Anterior teeth of the upper jaw clustered, awl-shaped; a median symphysial series in the lower jaw. Principal teeth of the upper jaw less laterally elongated, with fewer cusps than those of the lower jaw.

Notidanus microdon, Agassiz.

(Pl. xxxviii., figs. 4–7.)

Squalus (?), tooth of.	Mantell, G. A., 1822. "Foss. South Downs," p. 227, pl. xxxii., fig. 22.
Notidanus microdon.	Agassiz, L., 1843. "Poiss. Foss.," vol. iii., p. 221, pl. xxvii., fig. 1.
Notidanus microdon.	Reuss, A. E., 1846. "Verstein. böhm. Kreideform," pt. ii., p. 98. pl. xlii., fig. 8.
Notidanus microdon.	Giebel, C. G., 1848. "Fauna der Vorwelt," vol. i., p. 346.
Notidanus microdon.	Geinitz, H. B., 1850. "Charact. schicht. u. Petrefakt. Sachsböhm. Kreidegeb.," 2nd ed., p. 38, pl. ix., fig. 2.
Notidanus microdon.	Dixon, F., 1850. "Foss. Sussex," pl. xxx., fig. 30.
Notidanus microdon.	Geinitz, H. B., 1875. "Palæontogr.," vol. xx., pt. ii., p. 210, pl. xl., fig. 1.
Notidanus microdon.	Fritsch, A., 1878. "Rept. u. Fische böhm. Kreideform.," p. 12, woodcut, fig. 25.
Notidanus microdon.	Woodward, A. S., 1886. "Geol. Mag.," Dec. iii., vol. iii., p. 213, pl. vi., figs. 10–15.
Notidanus microdon.	Woodward, A. S., 1888. "Proc. Geol. Assoc.," vol. x., p. 287.
Notidanus microdon.	Woodward, A. S., 1889. "Cat. Foss. Fishes Br. Mus.," pt. i., p. 160.

Teeth of this genus occur in the collections from Lund. They are in the hard cherty chalk from Malmström. Of the three specimens two are from the upper jaw, and one from the lower. Of the former the most perfect is 0·012 m. in length along the base of the crown. The crown consists of four cones or denticles; the largest is 0·005 m. in height, and on its anterior margin is a series of four or five serrations; the posterior denticles are much less elongated as compared with the principal one; all are sharply pointed. The root is large, and equal in depth to the height of the largest cone; the external surface of the root is concave; the internal surface prominent near the base of the crown, retreating lower down, so that it forms, with the external surface, a very acute angle.

The second upper tooth is somewhat smaller, and is probably from a position

further back in the jaw. The principal cone is not relatively so much larger than those behind, as it is in the example already mentioned.

The tooth from the lower jaw is smaller than those from the upper, but exquisitely preserved. It is 0·010 m. in length. There is a series of nine cones diminishing gradually and uniformly from the principal one backwards. On the anterior margin of the first cone is a number of minute serrations. The root is deeper than the height of the longest cone, large and massive.

In the collection from the Zoological museum at Copenhagen specimens of *N. microdon* are preserved which have been obtained from the Nyere Kridt at Stevns, in Denmark; from Terkild-Skov, in the Island of Seeland; and in this museum, and also in the museum of the Geological Survey, there are numerous specimens, mostly fragmentary, from the coraline chalk of Faxe. The average size of the teeth from Faxe is much larger than those from the cherty chalk. The first denticle is proportionally not so high as compared with the succeeding ones as it is in the teeth of the upper jaw, already described, and the denticles have generally a more erect appearance.

A single representative of this species occurs in the collection of fishes from the Riksmuseum of Stockholm. The specimen is 0·007 m. in length; the crown consists of seven cones, each sharply pointed, slightly curved backwards, and diminishing in size from the anterior principal one. The first cone is 0·002 m. across the base, and 0·003 m. in height along the anterior border. The latter is provided along its lower half with a series of minute but well-marked denticulations. The root is not well preserved. Fragments appear to indicate that its depth was about equal to the height of the crown. This example is from the chalk of Limhamn, in the district of Malmä, in South Sweden.

Formation and Locality.—Etage Danien: Malmström; Stevns, in Denmark; Terkild-Skov, in the Island of Seeland; Limhamn, in the District of Malmä; and the coraline chalk of Faxe.

Ex coll.—Riksmuseum, Stockholm; Zoological Museum, Copenhagen; University Museum, Lund; Mineralogical Museum, University of Copenhagen.

Notidanus dentatus, A. S. WOODWARD.

(Pl. XXXVIII., fig. 8.)

Notidanus dentatus. WOODWARD, A. S., 1886. "Geol. Mag.," vol. iii., p. 214, pl. VI., figs. 17, 18.
Notidanus dentatus. DAVIS, JAMES W., 1888. "Trans. Roy. Dublin Soc.," N.S., vol. iv., p. 36, pl. VI., figs. 9–12.
Notidanus dentatus. WOODWARD, A. S., 1889. "Cat. Foss. Fishes in Brit. Mus.," pt. i., p. 159.

A single example of this species is preserved in the University's Mineralogical Museum at Copenhagen. It is a tooth of the lower jaw, and is, unfortunately, imperfect. Sufficient of the tooth is preserved to render its identification certain. The part preserved consists of the principal cone, and a second, smaller one, behind; whilst in front are six denticles; the length of the base of the crown is 0·02 m.; the height of the principal cone is 0·011 m., that of the second one is 0·008 m.; both are arched backwards. The denticles diminish gradually in size forwards. They, like the cones, are robust, rounded at the point, and whilst more or less curved backwards, are more erect than the cones. The root is not preserved.

The presence of denticles in the place of the ordinary serrated anterior margin of the tooth serves readily to distinguish this species. The original description by Smith Woodward was of teeth contained in a collection sent in 1876 to the British Museum by Sir James Hector, collected at Amuri Bluff in New Zealand. The single example of the teeth of the lower jaw possessed only three denticles on the anterior surface, and there were three additional cones behind the principal one. When describing the fossil fish remains of the Cretaceo-Tertiary formations of New Zealand, I was indebted to Sir James Hector for the loan of the Geological Survey collection from the Wellington Museum, which contained additional and better preserved specimens than those previously described. The characteristic denticles in front of the principal cone were found to reach five in number, whilst the same number of cones succeeded the largest one posteriorly. The specimen now described possessed a still larger number, and six denticles extended anteriorly; but the general character of the tooth appears to render its relationship beyond doubt; and although so widely separated from each other geographically, they are not widely separated in geological age.

No tooth has yet been identified belonging to the upper jaw, but it is not improbable that the dissociated cusps or denticles of the teeth may exist amongst the large number of teeth derived from the Faxe chalk.

Formation and Locality.—Etage Danien (Nyere Kridt): Faxe.

Ex coll.—Mineralogical Museum of the University of Copenhagen.

Family.—SCYLLIIDÆ.

Genus. **Scyllium.** Cuvier. "Règne Animal," vol. ii., p. 124. 1817.

First dorsal fin above or behind the pelvis; origin of the anal always in advance of that of the second dorsal; upper edge of the caudal fin not serrated. Teeth small, delicate, with a large middle cusp, and generally one or two smaller lateral cusps; arranged in numerous series.

Scyllium planum, Davis.

(Pl. xxxviii., fig. 9.)

Teeth having the characteristics of this genus have been found in the chalk-formation at Terkild-Skov in the Island of Seeland, and are comprised in the collection of the Zoological Museum of the University of Copenhagen, placed at my disposal by Prof. Dr. Lütken. They are small, and have probably been derived from the posterior portion of the lower jaw, though two or three teeth on each side the symphysis of the lower jaw are similar in form to the posterior ones, and these specimens may have been so situated. They have a breadth of 0·003 m. across the base of the crown. The principal median cone is only equal in height to half the breadth of the tooth; on each side is a lateral cone smaller than the median one. Each of the cones is rounded and somewhat thick at the base, tapering rapidly to a point with a slight curvature laterally. They are smooth. The base of the crown has a sygmoidal curvature. The root is short, and corresponds with the base in outline. Its outer surface slightly retreats from the base of the crown; the inner surface is expanded and bulbous.

The teeth from the chalk of Seeland are very similar to some of the teeth of the existing dogfish, *Scyllium canicula*, Cuv. Amongst fossil forms the nearest relationship will probably be found with *Scyllium* (*Thyellina*) *elongatum*,* Davis: in this species, from the soft chalk of Sahel Alma in Mount Lebanon, the central cusp is much longer than in these specimens; and apart from the difference due to the position in the mouth, the teeth have generally a more graceful and

* Trans. Roy. Dublin Society, N.S., vol. iii., p. 473, pl. xiv., figs. 2, 3.

delicate outline. Two species have been described by A. E. Reuss* from the Planerkalk of Bohemia and Saxony, under the names of *Scyllium crassiconum* and *Scyllium humboldti;* these were afterwards regarded by H. B. Geinitz,† and his determination was accepted by Anton Fritsch,‡ as distinct from the genus Scyllium, and they were transferred to the genus Scylliodus, Agass. The latter is considered by A. Smith Woodward § as synonymous with Scyllium, who thinks the two species of teeth are doubtfully associated with the genus. A comparison of the teeth now described with the plates cited, whilst exhibiting a superficial resemblance of the coronal portion, confirms the doubt expressed by Smith Woodward; the roots of the teeth are of different form, and wanting in breadth and definition; instead of the concave under-surface of Scyllium they are deeply convex.

Formation and Locality.—Etage Danien: Terkild-Skov in Seeland.

Ex coll.—Zoological Museum of the University of Copenhagen.

Family.—**LAMNIDÆ.**

Genus. **Scapanorhynchus.** A. S. Woodward. 1889. "Catalogue of Fossil Fishes in the British Museum," part i., p. 351.

Syn.—Rhinognathus. Davis, J. W., 1887. "Trans. Royal Dublin Society," N.S., vol. iii., p. 480.

Body slender; snout much elongated. Second dorsal fin small, placed immediately above a long anal. Caudal fin much elongated, inferiorly notched near the extremity; pectoral and ventral fins large. Anterior teeth with a long slender principal cusp, and mostly with a pair of minute lateral cusps; postero-lateral teeth wider, central cusp shorter.

This genus was instituted, with the name Rhinognathus, and embraced a number of fishes, mostly in an imperfect condition obtained from the upper cretaceous beds of Mount Lebanon collected by the Rev. J. F. Lewis, now in the Edinburgh and British Museums. Unfortunately the name had been preoccupied by Fairmaire as a name for a beetle, and a second was rendered necessary. This has been provided by my friend Mr. A. Smith Woodward in the Catalogue of the Fossil Fishes in

* Verstein. böhm. Kreideform, pt. i., p. 4, pl. ii., figs. 21, 22; pl. xii., fig. 11. (*Hybodus appendiculatus*) and pl. iv., figs. 4–8.

† Palæontographia, vol. xx., pt. i., p. 295, pl. lxv., fig. 8. 1875.

‡ Rept. u. Fische böhm. Kreideform, p. 11, fig. 22, and p. 11, fig. 21. 1878.

§ Cat. Foss. Fishes Brit. Mus., pt. i., p. 340. 1889.

the British Museum, and the genus has been found to embrace other species from various localities. From the Swedish chalk three species are added to the genus in the following pages.

Scapanorhynchus tenuis, Davis.

(Pl. xxxviii., figs. 10–13.)

Teeth small; crown attenuate, curved inwards and at its point slightly recurved; outer coronal surface and the apex smooth, inner surface minutely grooved on the basal portion; base, expanded laterally and supporting a minute sharply pointed denticle on each side; outer surface slightly convex; inner one rounded. Height of crown of anterior tooth 0·008 m.; width of the base equal to half the height. Latero-posterior teeth diminish in height to 0·004 m.; the width of the base is equal to the height; crown curved laterally, otherwise straighter than those in front. Root short; prominently bulbous on inner surface, outer one receding, inferior surface concave.

The teeth of this species, together with those of *S. latus*, next described, only exist in the Stockholm Collection from Oretorp. It is not without hesitation that it is proposed to separate them into two species. The step appears to be justified by the marked characteristics of the two, the graceful and slender attenuation of the crown in this species is very distinct from the broad, compressed crown of the next; the smaller dimensions of the base and the minute lateral denticles, whilst indicating close relationship, point to a specific difference.

Scapanorhynchus tenuis occurs in considerable abundance in the Faxekalk at Faxe and Annetorp, and has also been found in the Saltholmskalk at Herfölge, Grenaa, Lögstör and Raunstrüp. In the collection from the Zoological Museum of the University of Copenhagen are specimens from Faxe, collected by the late King Christian VIII. Teeth from the other localities named are comprised in the collections of the Mineralogical Museum of the University of Copenhagen.

Formation and Locality.—Etage Danien: Faxe; Herfölge; Grenaa, in Jutland; Logstor; Raunstrüp; Annetorp, Scania. Etage Senonian: Calshamn; Oretorp.

Ex coll.—Riksmuseum, Stockholm; Mineralogical Museum and Zoological Museum of the University of Copenhagen, Geological Museum of the University of Lund.

Scapanorhynchus latus, DAVIS.

(Pl. XXXVIII., figs. 14–17.)

Teeth broad in proportion to the height; outer coronal surface smooth, slightly convex, with a wide median sulcus at the base; the lower fourth of the height of the crown expands rapidly in breadth. Inner surface smooth and convex. A pair of lateral denticles attached to the broad base of the crown. Root thinner, antero-posteriorly, and the lateral bifurcations longer and deeper than in *Scapanorhynchus tenuis* from the same horizon. It also differs from the latter in the absence of grooves on the inner coronal surface; by its less rounded and attenuated form; and in the larger size and greater prominence of the lateral denticles.

This species is represented by examples from Annetorp in Sweden, in the Mineralogical Museum of the University of Copenhagen, kindly placed at my disposal by Prof. Johnstrup.

Formation and Locality—Etage Danien: Oretorp; Annetorp.
Ex coll.—Riksmuseum, Stockholm; Mineralogical Museum, Copenhagen.

Scapanorhynchus gracilis, DAVIS.

(Pl. XXXVIII., figs. 18–20.)

Teeth, median cone elevated, compressed, acuminate, smooth, expanding widely at the base, and having on each side a well developed lateral denticle erect and acutely pointed. Anterior teeth curved sygmoidally; the curvature of the posterior teeth is less decided, but they are inclined obliquely towards one or other side. Height of crown 0·012 m. in an anterior example; a latero-posterior tooth is 0·010 m., and the breadth of the base is equal to the height; the lateral denticles average one-fifth the height of the crown. Root short, prolonged laterally beyond the crown, inner surface prominent, outer one concave, inferior surface broad and concave. The teeth exhibit considerable variety in form, but are all characterized by the lateral denticles occupying a position allowing a perceptible interval between them and the median cone.

This species approaches *Scapanorhynchus? subulatus*, Ag.; it is distinguished by the lateral denticles standing erect from the base; those in *S. subulatus* are inclined at an oblique angle outwards. The teeth situated in the several parts of the jaws are generally similar in form to those figured of the type specimen

of the genus *S.* (*Rhinognathus*) *lewisii*, Davis ("Trans. Roy. Dublin Soc.," N. S., vol. iii., p. 480, pl. xiv., fig. 4), from the cretaceous beds of Sahel Alma, Mount Lebanon, so far as the crown is concerned, but the roots of the anterior teeth of *S. lewisii* are deeply pronged; in this species they are short and widely distended.

Formation and Locality.—Danien: Faxe or Coraline Limestone, Annetorp. Lower Senonien: Oppmanna.

Ex coll.—Geological Museum, University of Lund.

Genus. **Odontaspis.** Agassiz. 1838. "Rech. sur les Poiss. Foss.," vol. iii., p. 87.

Second dorsal fin and the anal of equal size, scarcely smaller than the first dorsal. No pit at the root of the caudal; side of the tail without keel. Teeth of all but the few hindermost series with a long, tapering, acuminate median cone with smooth cutting edges, base expanded with one or more pairs of lateral denticles, larger and sharper than those of Lamna; fourth tooth from the symphysis upon each side of the upper jaw very small; the teeth of the most anterior pair in the lower jaw small and relatively very slender.

Agassiz regarded Odontaspis as a sub-genus of Lamna; Müller and Henle considered that it was a distinct and well-defined genus, a view since accepted by Dr. Günther, and more recently by A. Smith Woodward, with considerable modification. The remains of this genus are found in the Cretaceous series of rocks, are abundant throughout the Tertiary formations, and still continue represented at the present time by a few surviving species.

Odontaspis acuta, Davis.

(Pl. xxxviii., figs. 21–24.)

1888. "Trans. Roy. Dublin Soc.," N. S., vol. iv., p. 22, pl. v., figs. 1, 2.

Teeth lanceolate, slender, curved sygmoidally, sharply pointed, expanded base, with two pairs of lateral denticles acutely pointed and curved towards the central crown. In the anterior teeth the crown rises to a height of 0·020 m., with a width at the base of 0·005 m. The root between the bases of the second denticle on each side is double that of the base of the crown in width. The outer coronal surface is slightly convex, more or less depressed in the median

portion at the base; the latter deeply concave. Inner coronal surface convex, smooth, projecting at the base; lateral margins fine, smooth. Root deeply bifurcated in the anterior teeth; the depth of the bifurcation diminishes in the teeth situated latero-posteriorly; forms a prominent bulb on the inside, with a corresponding depression externally. A median groove or sulcus extends vertically across the prominent part of the root. The posterior teeth have a much shorter crown, and the width of the root is greater; the latter in some of the teeth exceeding the former.

The teeth vary considerably in size, apparently according to age rather than a difference in the size of the mature fish. The smaller teeth are more slender, more acutely pointed, and have finer cutting edges than the larger ones, and have been subject to less attrition from use. The base, whilst possessing all the characters of the larger examples, has those characters less markedly developed, and, agreeing with the crown, of a more attenuated nature.

Whilst the teeth now described are in many respects similar to *O. hopei*, Ag., *O. dubia*, Ag., and *O. subulata*, Ag., they differ from all of them in possessing two pairs of lateral denticles, and in this character they approach *Odontaspis acuta*, Davis, from the Oligocene (Oamaru) formations of New Zealand. The example from the Danien locality of Annetorp, the highest horizon from which the teeth have been obtained (fig. 21), is remarkably similar to the example from Trellissic ("Trans. Roy. Dublin Soc.," N. S., vol. iv., pl. v., fig. 2), whilst those from Oppmanna more closely approximate to the specimen represented by fig. 1 (*op. cit.*).

In the Danish collections this species is represented by specimens, two of which are figured, from Faxe, Stevns, Annetorp, Luneberg, and Saltholm. The specimen from Stevns (Pl. XXXVIII., fig. 23) is from the former collection of the late King Christian VIII. of Denmark.

Formation and Localities.—Etage Danien: Annetorp; Stevns; Faxe; Luneberg. Senoniam II.: Oppmanna.

Ex coll.—Geological Museum, University of Lund; Riksmuseum, Stockholm; Mineralogical Museum, University of Copenhagen; Zoological Museum, University of Copenhagen.

Odontaspis acutissima, Agassiz.

(Pl. xxxviii., fig. 25.)

Odontaspis acutissima. Agassiz, L., 1843. "Poiss. Foss.," vol. iii., p. 294, pl. xxxvii. *a*, figs. 33, 34.
Odontaspis acutissima. Giebel, C. G., 1848. "Fauna der Vorwelt," vol. i., p. 363.
Odontaspis acutissima. Bassano, F., 1879. "Atti. Soc. Veneto. Trent. Sci. Nat.," vol. vi., p. 56.
Odontaspis acutissima. Woodward, A. S., 1889. "Cat. Foss. Fishes in Brit. Mus.," pt. i., p. 374.

M. Agassiz designated under the above name teeth with a sharp point and long, cylindrical, sharp-pointed lateral cones. The origin of the tooth which forms the type of the species was unknown. A second example, associated with it provisionally, was derived from the molasse of Berthoud. The tooth represented (Plate xxxviii., fig. 25) possesses the characters ascribed by Agassiz to the species, and differs from others already noticed from the Swedish or Danish Cretaceous rocks. The height of the median crown is 0·008 m., and the breadth of the base is the same. The lateral cones are 0·003 m. in height, more than one-third the height of the crown. The root is short, retreating from the external base, concave below, and having the form of the base of the crown. The central cone is convex on both the inner and outer coronal surface; the lateral margins are sharp, and the apex pointed. The lateral denticles are well developed, very long and sharply pointed. A number of striæ extend from the base towards the apex of each. The example is rather smaller than the one described by Agassiz, otherwise it appears to possess all its characteristics.

This species is distinguished from *Odontaspis acuta*, Davis, by its more graceful and slender form; the great size and prominence of the erect lateral denticles, of which there is only one on each side; as compared with the more or less curved denticles, generally two on each side, and comparatively small size in *O. acuta*, Davis.

Formation and Locality.—Etage Danien (Myere Kridt): Faxe.

Ex coll.—Mineralogical Museum, University of Copenhagen.

Odontaspis faxensis, Davis.

(Pl. xxxviii., fig. 26.)

Teeth small; the crowns of the anterior teeth on their external surfaces attaining a height of 0·01 m.; erect, acuminate. External coronal surface convex and smooth; internal one still more convex and also smooth; very slight ridge along each lateral margin. Base of crown expands laterally to a width of 0·012 m., and supports on each side a series of three denticles, decreasing in size as they recede from the principal cone; the denticles are short, conical, and sharply-pointed. The base of the crown is concave. The root is short, with a spongy structure, conforming in outline to that of the base of the crown.

This form is distinct from any other observed in the Cretaceous rocks of Sweden and Denmark. It, perhaps, most closely approaches *Odontaspis acuta*, Davis; but in that species there does not appear to be more than two lateral denticles, the second being much inferior in size to the first. In this species there are three lateral denticles on each side; all robust and distinct, and diminishing gradually in size from the centre.

Formation and Locality.—Etage Danien: Faxe.

Ex coll.—Mineralogical Museum, Copenhagen University.

Odontaspis kopingensis, Davis.

(Pl. xxxviii., figs. 27, 28.)

Teeth strong and robust; crown attains a height of 0·015 m.; on the median line, conical and pointed; external surface very slightly convex, smooth; internal surface deeply convex, rendering the crown very thick and strong. The base of the crown is curved upwards transversely, slightly on the external face, deeply on the internal; it is 0·015 m. across. A single pair of lateral denticles are present. They are triangular, and the apex of each is pointed. The root is large, deeply forked; the prongs well advanced on the external face; and the median part very prominent on the internal one.

The teeth comprised in this species appear to be rare; a single specimen occurs in the Riksmuseum at Stockholm from Saltholm, and another in the Geological Museum of the University of Lund from Kopinge. It most nearly approaches *Odontaspis acuta*, Davis, in general appearance; but the triangular and somewhat blunt character of the lateral denticles extending at right angles from the crown, are very different from the slender acuminate denticles, curving inwards towards the crown, of *Odontaspis acuta*. In this species there is no trace

of a second pair of denticles. In equally well preserved specimens of *O. acuta* there are generally two pairs.

It is significant, and confirms to some extent the isolation of this species, that at Kopinge and Saltholm the teeth of *O. acuta* have not been found; whilst in the localities in which that species occurs in abundance this remains undiscovered.

Formation and Locality.—Etage Danien: Saltholm. Etage Senonien (zone with *Belemnites mucronatus*): Kopinge, in the District of Ystad.

Ex coll.—Riksmuseum, Stockholm; Geological Museum, University of Lund.

Genus. **Oxyrhina.** AGASSIZ. "Recherches sur les Poissons Fossiles," vol. iii., pp. 86 and 276.

Second dorsal fin and the anal very small. A pit at the root of the caudal fin, which has the lower lobe much developed; side of the tail with a keel. Teeth medium size, acutely triangular, compressed, slender, margins smooth, point acute, without lateral denticles. Posterior teeth, base broad as compared with the height, the teeth becoming smaller, shorter, and triangular.

Oxyrhina was regarded by Agassiz as nearly related to Lamna, being distinguished by its more compressed form, and the absence of lateral denticles. It occurs fossil in the Jurassic rocks, in the Cretaceous, and most abundantly in the Tertiary formations. The genus is represented by one existing species.

Oxyrhina mantelli, AGASSIZ.

(Pl. XXXIX., figs. 1–7.)

Squalus zygæna ? . . . MANTELL, G. A., 1822. "Foss. S. Downs," p. 227, pl. XXXII., figs. 4, 7, 8, 10, 11, 26, 28.

Oxyrhina, ... GEINITZ, H. B., 1839 (*Ex. Ag.*). "Charact. Schicht. u. Petrefakt. Sächs.-böhm. Kreidegeb.," p. 12, pl. I., fig. 4 (in part).

Oxyrhina mantelli, . . AGASSIZ, L., 1843. "Poiss. Foss.," vol. iii., p. 280, pl. XXXIII., figs. 1–5 (*non* fig. 6), 7–9.

Oxyrhina mantelli, . . REUSS, A. E., 1845. "Verstein. böhm. Kreideform.," pt. i., p. 5, pl. III., figs. 1, 3, 5, 6 (? figs. 2, 4).

Oxyrhina mantelli, . . GIEBEL, C. G., 1848. "Fauna der Vorwelt.," vol. i., p. 357.

Oxyrhina mantelli, . .	GIBBES, R. W., 1849. "Journ. Acad. Nat. Sci. Philad." [2], vol. i., p. 202, pl. XXVII., fig. 158.
Oxyrhina mantelli, . .	DIXON, F., 1850. "Foss. Sussex," pl. XXX., fig. 24.
Oxyrhina mantelli, . .	GERVAIS, P., 1852. "Zool. et Pal. Français," pl. LXXVI., figs. 3, 20.
Oxyrhina mantelli, . .	KNER, R., 1852. "Denkschr. k. Akad. Wiss. Wien.," vol. iii., pl. XV., fig. 3.
Oxyrhina mantelli, . .	FISCHER, C. E., 1856. "Allg. deutsch. naturh. Zeit. Dresden," N. S., vol. ii., p. 141, pl. II., fig. 43.
Oxyrhina mantelli (subinflata),	SAUVAGE, H. E., 1867. "Cat. Poiss. Form. Second Boulonnais" (Mem. Soc. Acad. Boulogne, vol. ii.), p. 71, pl. III., fig. 16.
Oxyrhina mantelli, . .	ROEMER, F., 1870. "Geol. Oberschlesien," p. 323, pl. XXXVI., figs. 3–5.
Oxyrhina mantelli, . .	SAUVAGE, H. E., 1872. "Bibl. Ecole Hautes Etudes," vol. v., No. 9., p. 21, figs. 33–35.
Otodus oxyrhinoides, . .	SAUVAGE, H. E., 1872. *Loc. cit.*, p. 24, figs. 39–41, 54–56.
Oxyrhina extenta, . .	LEIDY, J., 1873. "Ext. Vert. Fauna W. Territ" (Rep. U. S. Geol. Surv. Ter., vol. i., pt. i.), p. 302, pl. XVIII., figs. 21–25.
Oxyrhina mantelli, . .	ST. ZARECZNEGO, 1874. "Sprawozd. Komisyi Fizyjograf. Galicyi," vol. viii., p. (126).
Oxyrhina mantelli, . .	GEINITZ, H. B., 1875. "Palæontogr." vol. xx., pt. ii., p. 207, pl. XXXVIII., figs. 1–21.
Oxyrhina mantelli, . .	ST. ZARECZNEGO, 1878. *Loc. cit.*, vol. xii., p. (203).
Oxyrhina mantelli, . .	FRITSCH., A., 1878. "Rept. u. Fische böhm. Kreideform," p. 7, woodcut, fig. 12.
Oxyrhina mantelli, . .	WOODWARD, A. S., 1888. "Proc. Geol. Assoc.," vol. x., p. 291.
Oxyrhina mantelli, . .	WOODWARD, A. S., 1889. "Cat. Foss. Fishes in Brit. Mus.," p. 376., pl. XVII., figs. 9–21.

Teeth "moderately robust; outer coronal face always nearly flat, often with large vertical wrinkles; inner coronal face gently rounded; root short, the branches very divergent, thick, expanded, and abbreviated. Anterior teeth large, triangular, and comparatively broad, the crown only gently curved outwards at

the apex; lateral teeth having the root much wider than the main portion of the crown, which thus exhibits a sudden basal expansion behind, and often, also, in front."—(A. S. W.).

The teeth of this species are smaller than those found in the English chalk, and whilst offering great diversity in form, as exhibited in the specimens represented (Plate xxxix., figs. 1–7), the small teeth, very short and extremely broad, which Smith Woodward * represents as occupying the posterior portion of the jaws, are not represented. The root is deeper but less divergent laterally than those hitherto described; the external surface is deeply concave; the internal surface exhibits a correspondingly prominent convexity. The oblique teeth from the posterior portion of the jaw do not possess so great an expansion of the internal surface of the root as those in front; the root is flatter, as well as more greatly expanded laterally.

In the Danish collections this species is represented by examples from the chalk of Saltholm and Annetorp; all in the Mineralogical Museum.

Oxyrhina mantelli has a very wide range both in time and the area over which its remains have been discovered. It is a common fossil in the chalk of the south of England, and is found in the Cretaceous rocks of Sarthe, in the north of France, in Belgium, Germany, Bohemia, Galicia, Russia, Sweden, and Denmark; and in America it has been found in the Cretaceous beds of Kansas, the Mississippi, and Alabama, and a closely related species, *Oxyrhina haasti*, Davis, has been discovered in New Zealand.

Formation and Locality.—Etage Danien: Saltholm; Annetorp and Limhamn Skåne. Etage Senonien (zone with *Actinomax mamillatus*): Oppmanna; most abundantly at the latter.

Ex coll.—Geological Museum, University of Lund; Riksmuseum, Stockholm; Mineralogical Museum of the University of Copenhagen.

Oxyrhina lundgreni, Davis.

(Plate xxxix., figs. 8–13.)

The teeth comprised in this species exhibit considerable variation in form and size. The anterior teeth are long, erect, with a slightly recurved apex; those which have occupied an intermediate position on the sides of the jaws are shorter, with a broader base and greater curvature; whilst the posterior teeth are little more than half the length of those occupying an anterior position, and

* Cat. of Foss. Fishes in the British Museum, part. i., pl. xvii., figs. 9–21.

have a decidedly sygmoidal curvature combined with a peculiar twist outwards towards the apex.

The length of the anterior teeth is 0·05 m., the lateral diameter, midway between the base and the apex, is 0·012 m.; the lateral margins are produced so as to form a fine cutting surface, and gradually converge to an acuminate apex; towards the base the tooth thickens, and rapidly expands to a diameter of 0·025 m. The enamelled surface is invariably smooth near the point; in some examples the internal surface maintains this character quite to the base, whilst the external is only slightly grooved; in others deep channels extend from the base far towards the apex on both the internal and external surfaces, usually more pronounced on the latter. The channels are divided into more numerous, but smaller, grooves at the base. The external surface of the anterior teeth is less rounded than the internal one; in those teeth situated posteriorly the curvature of the two surfaces is about equally well developed. The root is not well preserved in any of the Swedish examples, but sufficient remains on some of the specimens to show that it was much wider than the crown, and that the internal surface was produced so as to form a prominent median bulb. The posterior teeth are less deeply grooved, and more rapidly and uniformly converge to a point than the anterior ones: an average length is 0·03 m., with a lateral diameter of 0·017 m. at the junction of the enamelled surface with the root.

A beautifully preserved specimen, showing the crown and root of a tooth, which occupied a lateral position in the jaw, occurs in the Mineralogical Museum at Copenhagen. It is embedded in a matrix of the coraline limestone or chalk of Faxe. To some extent this is unfortunate, because the internal surface of the root is hidden by the matrix; but it is very probable that the fact of its being attached to the matrix has preserved the crown and root intact. The examination of many hundreds of specimens has shown that the attachment of the crown to the root is more or less fragile, and the root being apparently less easily detached from the matrix than from the crown the two parts are rarely found associated. It may be imagined, however, that a more careful search in the limestone forming the matrix at the base of the crown would result in the discovery of many other examples of the root. The height of the crown in this specimen is 0·035 m., and its width across the exposed external surface is 0·012 m. The crown is curved slightly backwards, and at the same time exhibits a sygmoidal curvature of the inner and outer surfaces. The outer surface is deeply grooved from the base upwards; the inner one smooth; the margins have a sharp cutting edge, and the apex is acuminate. The root extends at an obtuse angle from each margin of the crown, forming a pair of processes expanding to a diameter of 0·032 m., nearly equal to the height of the crown. The under surface of the root is only slightly concave. The total height of the

tooth, from the anterior extremity of the base of the root to the tip of the crown, is 0·05 mm. The root has apparently an open and porous structure.

These teeth present a considerable divergence from the usual characteristics of the genus Oxyrhina in the long erect crown, and more especially in the wide separation of the lateral extensions and the peculiar flat under-surface of the root. It may at some time be found desirable to make it the type of a new genus; and it is not without hesitation that I have placed it as a distinct species in the genus Oxyrhina.

This species approaches in form to that of *Oxyrhina grandis*, Davis, from the Cretaceo-Tertiary beds of New Zealand. It may be distinguished by its greater length as compared with the width, its more erect and less triangular form, and the presence of deep grooves extending vertically on the external, and, in most cases, on the internal, surface.

The teeth are abundant in the Faxekalk ; and numerous specimens from Faxe are in both the Mineralogical and Zoological Museums of the University of Copenhagen. Specimens from Saltholm also occur in each collection, and others from Annetorp are in the former.

Formation and Localities.—Étage Danien and Étage Sénonien, in zones 1 and 2 : Limhamn, in the District of Malmå ; Annetorp ; Faxe ; Köpinge, in the District of Ystad ; Saltholm ; and Oppmanna, in the District of Kristianstad.

Ex coll.—Riksmuseum, Stockholm ; Geological Museum, University of Lund ; Mineralogical and Zoological Museums of the University of Copenhagen.

Oxyrhina zippei, Agassiz.

(Pl. xl., figs. 1–7.).

Oxyrhina zippei, . . . Agassiz, L., 1843. "Poiss. Foss.," vol. iii. p. 284, pl. xxxvi., figs. 49–52 ; *non* fig. 48.

Oxyrhina zippei, . . . Pictet, F. J., 1845. "Paléontologie," vol. ii., p. 276.

Oxyrhina zippei, . . . Giebel, C. G., 1848. "Fauna der Vorwelt," p. 357.

Oxyrhina zippei, . . . Sauvage, H. E., 1872. "Bibl. Ecole Hautes Études," vol. v., No. 9, p. 23.

Oxyrhina zippei, . . . Woodward, A. S., 1889. "Catalogue of the Fossil Fishes in the British Museum," pt. i., p. 392.

Teeth acuminate, slender, compressed; enamel smooth; with or without

slight vertical grooves from the base upwards on the outer coronal surface, giving it the appearance of a median depression; laterally the crown exhibits a sigmoidal curvature; height 0·018 m.; breadth at base of crown 0·009 m.; outer coronal surface slightly convex below, flat above; inner surface equally convex with the outer; margins thin and sharp. Base of crown concave and receding on the outer; prominent and overlapping the root on the inner surface; laterally wide and expanded; no lateral denticles. Root short, compressed antero-posteriorly like crown; laterally extending beyond crown, with bluntly-terminating divergent branches; base with comparatively slight concavity. Postero-lateral teeth broader, shorter, and more acutely pointed.

These teeth are separated from *Odontaspis elegans*, Ag., by the total absence of lateral denticles, and, though superficially resembling them in form, they are thinner and more compressed. The posterior teeth are broader and shorter, as compared with the anterior ones, than in *O. elegans.* The broadest teeth approach *Oxyrhina enysii*, Davis, a species found in the Senonian formations of Oamaru and Waipara in New Zealand. (" Trans. Roy. Dublin Society," N.S., vol. iv., p. 28, pl. v., figs. 17–20.)

They appear to be most closely associated with, and to possess the characteristics ascribed by Agassiz to a number of small teeth from the Greensand of Ratisbon (" Poiss. Foss.," vol. iii., p. 284, pl. xxxvi., figs. 49–52). Agassiz was in doubt as to the presence of lateral denticles, because the roots and a portion of the base in the examples at his disposal were broken off. With the specimens from the Swedish Cretaceous rocks this point is made clear; the base and roots are well preserved, and there are no lateral denticles. Fig. 48 (*op. cit.*), which Agassiz included in this species, H. E. Sauvage considers to be the lateral denticle of a large tooth of Otodus from the white Chalk of Villavard, which is described as *O. spathula* (" Rech. sur les Poiss. Foss. du terrain Crétacé de la Sarthe," " Bibl. Ecole des Hautes Etudes," vol. v., pp. 23 and 33). The type of *O. zippei*, represented in the figures 49–52, and with fig. 48 eliminated, agrees with the examples from Oppmanna, and the latter appear to be naturally included in the species.

Formation and Locality.—Lower Senonian: Oppmanna, Oretorp.

Ex coll.—Geological Museum, University of Lund; Riksmuseum, Stockholm.

Oxyrhina conica, Davis, sp. nov.

(Pl. xl., figs. 8–10.)

Teeth small; anterior teeth long, tapering to a sharp point, with a more or less sigmoidal curvature; posterior teeth broader at the base, shorter, and with a scarcely perceptible curvature. Height of anterior tooth 0·008 m.; breadth of base 0·003 m.; outer coronal surface flat on the lower, slightly convex on the upper, part, with minute ridges at the base, which disappear higher, leaving an even and smooth surface; inner coronal surface convex, with similar ridges near the base to those on the outer face; margin of base curved upwards in centre. Root extended beyond the base of the crown laterally, and on the inner surface; postero-inferior surface flattened, or slightly concave. No evidence of lateral denticles. The root in several examples is well-preserved; in the majority, however, it is broken away, and only the outer shell of the tooth is preserved.

Two specimens somewhat larger, but possessing the characters of this series, have been found at Köpinge.

The entire absence of lateral denticles on the teeth which are sufficiently well preserved to afford evidence leads to the inference that the whole of the teeth have probably been devoid of them. They are similar in form to a number of teeth found in the Pondicherry Beds of India, and described by Sir Philip Egerton in the "Quarterly Journal of the Geological Society," vol. i., p. 171. They were imperfectly preserved, and were referred to the genus Odontaspis, with the specific appellation, *O. constrictus*. Although it is devoid of lateral denticles, Egerton considers that more perfect specimens might possess them; and he indicated a probable relationship to *Lamna* (*Odontaspis*) *subulata*, Agassiz, from the Lower Greensand of Neufchâtel ("Poiss. Foss.," vol. iii., p. 296, pl. xxxvii. *a*, fig. 5). The latter has well-developed lateral denticles, and a deeply-forked root. The Pondicherry teeth have a similarly flat inferior surface to one of the specimens now described, so far as can be ascertained from the imperfect specimens. Later, A. Smith Woodward has transferred *Odontaspis subulata*, Ag., to the genus Scapanorhynchus ("Catalogue of the Fossil Fishes in the British Museum," pt. i., p. 356), and has included *O. constrictus*, Eg., as a synonym of the same species.

The Oretorp specimens are clearly distinct from *O. subulata*, Ag., and the absence of lateral cusps removes them from the genus Scapanorhynchus, and indicates their relationship with Oxyrhina; it is therefore proposed to place them in that genus.

Formation and Locality.—Senonian: Oretorp, Köpinge (?).

Ex coll.—Riksmuseum, Stockholm.

Vertebræ of Oxyrhina mantelli, Ag.

(Pl. XXXIX., fig. 14.)

Examples of vertebræ of Oxyrhina occur at Köpinge, in the Étage Sénonien, characterized by the presence of *Belemnitella mucronata.* The vertebræ have a diameter of about 0·06 m., and are 0·015 m. in thickness. The anterior and posterior surfaces are deeply biconcave, with the centre pierced. The concave surfaces of the vertebra are marked by a series of concentric rings, giving a more or less corrugated appearance, represented in the figure.

Formation and Locality.—Upper Senonian: Köpinge.

Ex coll.—Geological Museum of the University of Lund, Sweden.

Genus. **Lamna.** CUVIER, "Règne Animal," vol. ii., p. 126, 1817; AGASSIZ, L., 1843, "Rech. sur les Poiss. Foss.," vol. iii., p. 287.

Teeth of medium size, elongated, narrow in proportion to the height, sharply pointed, with cutting edge smooth, base expanded, lateral denticles present, usually one pair; root large and deeply bifurcated.

The teeth of Lamna may be distinguished from those of Otodus by being rounder and less compressed, and having the lateral cones smaller and pointed.

Oxyrhina is devoid of lateral denticles, and is thinner and more triangular in outline than Lamna. This latter genus first appears in the Chalk formation, and is still existing.

Lamna elegans, Agass.

(Pl. XL., figs. 11–17.)

Dentes squali, . . . BRANDER, G., 1776. "Foss. Hantoniensia," pl. IX., figs. 113–114.

Lamna elegans, . . . AGASSIZ, L., 1843. "Poiss. Foss.," vol. iii., p. 289, pl. XXXV., figs. 1–5. (*non* figs. 6, 7); pl. XXXVII. *a*, fig. 50 (*non* fig. 58).

Lamna elegans, . . . GIEBEL, C. G., 1848. "Fauna der Vorwelt," vol. i., p. 359.

Lamna elegans, . . . Gibbes, R. W., 1849. "Journ. Acad. Nat. Sci. Philad." [2], vol. i., p. 196, pl. xxv., figs. 98–102 (? figs. 96, 97).

Lamna elegans, . . . Dixon, F., 1850. "Foss. Sussex," p. 203, pl. x., figs. 28–31.

Lamna elegans, . . . Gervais, P., 1852. "Zool. et Pal. Franç.," pl. lxxv., fig. 3.

Lamna elegans, . . . Schafthäutl, K. E., 1863. "Süd.-Bay. Leth. Geogn.," p. 242, pl. lxii., fig. 6.

Lamna elegans, . . . Le Hou., H., 1871. "Prelim. Mém. Poiss. Tert. Belg.," p. 12.

Lamna elegans, . . . Rutot., A., 1875. "Ann. Soc. Géol. Belg.," vol. ii., p. 34.

Lamna elegans, . . . Winkler, T. C., 1876. "Archiv. Mus. Teyler," vol. iv., p. 9.

Lamna elegans, . . . Vincent, G., 1876. "Ann. Soc. Roy. Malacol. Belg.," vol. xi., p. 123, pl. vi., fig. 4.

Lamna elegans, . . . Locard, A., 1877. "Faune Terr. Tert. Moy. Corse.," p. 5.

Lamna elegans, . . . Winkler, T. C., 1880. "Archiv. Mus. Teyler," vol. v., p. 74.

Lamna elegans, . . . Geinitz, H. B., 1883. "Abh. Naturw. Ges. Isis Dresden," p. 5, pl. i., figs. 4–6.

Lamna elegans, . . . Noetling, F., 1885. "Abh. Geol. Specialk. Preussen u. Thüring. Staaten," vol. vi., pt. iii., p. 61, pl. iv.

Odontaspis elegans, . . Woodward, A. S., 1889. "Cat. Foss. Fishes in Brit. Museum," pt. i., p. 361.

A large number of teeth have been found in the Senonian rocks at Oppmanna, and in other localities less abundantly, which present the characteristic appearance of *Lamna elegans*, Agass., and associated with them are teeth, shorter, broader at the base, and having the fangs of the root more widely separated, which have probably been located in the posterior parts of the jaws of the same species. Anterior teeth elongated and narrow, varying in size, the longest attaining a height of 0·035 m. from the base of the enamelled crown to the point; the width at the base is 0·007 m. The outer coronal surface is distinctly convex on the lower half, flatter above; smooth, except a few faint striations at the base; inner face deeply convex and smooth; lateral margins produced, very thin, and sharp. The crown is slightly curved, in some specimens scarcely perceptible. The root is

rarely preserved perfect; deeply bifurcated; outer surface concave, retreating directly from the base of the crown; inner surface bulbous and prominent; lateral branches separated at a right angle. A minute lateral denticle is occasionally preserved, tipped with enamel, and slightly separated from the principal cone. The posterior teeth are broader, shorter, and more compressed than the anterior ones. A tooth apparently proportionate in size to those described above is 0·025 m. in height and 0·010 m. in width; its outer surface is flatter, and the inner less convex, whilst its curvature is more pronounced than is that of the anterior teeth; the branches of the root are smaller and more widely separated, and the inner surface is less bulbous.

This species is most abundantly represented in the Swedish collections from the Senonian formation at Oppmanna; whilst to the Danish collections the Faxe and Annetorp beds, in the Danian series, have contributed most largely. It may be noted that the specimens from Faxe are very abundant, but they are generally smaller than those from Annetorp.

Formation and Localities.—Étage Danien: Faxe Limestone: Saltholm; Annetorp; Limhamn; Malmå district. Étage Sénonien Inferieur: Kjuge, Scania; Ifo; Oppmanna; District of Kristianstad; Sissebäck.

Ex coll.—Geological Museum, Lund University; Riksmuseum, Stockholm.

Lamna incurva, Davis.

(Pl. xl., figs. 18–24.)

Lamna incurva, . . . Davis, J. W., 1888. "Trans. Roy. Dublin Soc.," ser. ii., vol. iv., p. 17, pl. iii., figs. 2–5.

Odontaspis incurva, . . Woodward, A. S., 1889. "Cat. of Foss. Fishes in the Brit. Museum," p. 372.

Teeth robust; crown smooth, with marked sigmoidal curvature; height of anterior teeth 0·020 m.; breadth at the base 0·005 m., from which the tooth tapers to a point; outer coronal surface convex; inner surface deeply convex; the lateral margins form a cutting edge near the apex; nearer the base the sides of the teeth are rounded. A comparatively small number of specimens possess a single pair of lateral denticles, minute and sharp-pointed. The crown of the posterior teeth is shorter than that of the anterior ones; it is broader, more rapidly acuminate and compressed. The root is prominently bulbous on the inner surface; a deep vertical notch extends along it; lower, the root is divided into two fangs, at no great distance apart in the front teeth, but much more widely separated in those situated behind.

This species, instituted for the reception of teeth from the Cretaceo-Tertiary strata of New Zealand, is now found to occur in the Cretaceous system of Sweden. The teeth from the latter locality are, however, smaller than the type specimens from New Zealand. In addition to the examples sent from the museums in New Zealand, several specimens are recorded by Mr. A. Smith Woodward which are in the collections at the British (Natural History) Museum, all from localities in New Zealand.

A small number of teeth have been obtained from the Faxe limestone at Annetorp, and are included in the Lund collections. From Oppmanna the number of examples is much larger; and it is from this locality that the types have been selected which are represented on Plate XL. There is no appreciable difference, however, in the teeth from the two formations.

Numerous specimens are comprised in the Danish Collections, principally derived from the Saltholmkalk.

Formation and Localities.—Étage Danien: Faxe Limestone: Annetorp; Saltholm; Luneberg; Limhamn, Skåne; Faxe. Étage Sénonien II.: Oppmanna; Sissebäck. Étage Sénonien I.: Kjuge.

Ex coll.—Geological Museum, Lund University; Riksmuseum, Stockholm (Sissebäch); and Limhamn Mineralogical and Geological Museums of the University of Copenhagen.

Genus. **Otodus.** Agassiz, 1843. "Rech. sur les Poissons Fossiles," vol. iii., p. 266.

This genus is defined by Agassiz as occupying an intermediate position between Carcharodon and Lamna or Oxyrhina. It may be distinguished from Oxyrhina by the presence of a well-defined lateral denticle on each side the median cone, more frequently rounded than compressed or pointed. The median cone is broad and compressed; similar in form to that of Oxyrhina. In Lamna and Odontaspis the lateral denticles are smaller, more cylindrical and pointed, and the teeth generally more elongated. The absence of marginal serrations serve to distinguish this genus from Carcharodon. The root is largely developed and thick, but is devoid of the deep lateral projection which distinguishes Lamna.

This genus is found abundantly in the Cretaceous and Tertiary formations, but, so far as known, has since ceased to exist.

Otodus appendiculatus, Agassiz.

(Pl. XLI., figs. 1–11.)

Dent de Squale, . . . FAUJAS ST. FOND, 1799. "Hist. Nat. Mt. St. Pierre de Maestricht," p. 110, pl. XVIII., fig. 2.

Squalus mustellus (?), . . MANTELL, G. A., 1822. "Foss. S. Downs," pl. XXXII., figs. 2, 3, 5, 6, 9.

Squalus cornubicus, . . GEINITZ, H. B., 1839. "Charact. Schicht. u. Petrefact. böhmsachs. Kreideform.," pp. 11, 12, pl. I., figs. 3, 5.

Odontaspis rhaphiodon, . . GEINITZ, H. B., 1839. *Op. cit.*, pp. 11, 12, pl. I., figs. 3, 5.

Otodus appendiculatus, . . ROEMER, F., 1841 (*ex* Agassiz MS.). "Nordd. Kreidegeb.," p. 107.

Otodus appendiculatus, . . AGASSIZ, L., 1843. "Poiss. Foss." vol. iii., p. 270, pl. XXXII., figs. 1–25.

Otodus appendiculatus, . . REUSS., A. E., 1845. "Verstein. böhm. Kreideform.," pt. i., p. 5, pl. III., figs. 23–29 (? figs. 30, 31, *non* fig. 22).

Otodus appendiculatus, . . GIEBEL, C. G., 1848. "Fauna der Vorwelt Fische," p. 353.

Otodus basalis (?), . . GIEBEL, C. G., 1848. "Fauna d. Vorw. Fische," p. 354.

Otodus appendiculatus, . . GIBBES, R. W., 1849. "Journ. Acad. Nat. Sci. Philad. II.," vol. i., p. 199, pl. XXVI., figs. 138–140.

Otodus appendiculatus, . . DIXON, F., 1850. "Foss. Sussex," pl. XXX., fig. 25; pl. XXXI., fig. 17.

Otodus latus (?), . . . GERVAIS, P., 1852. "Zool. et Pal. Franç.," pl. LXXVI., fig. 23.

Lamna acuminata (?), . . GERVAIS P., 1852. *Op. cit.*, pl. LXXVI., figs 12–24.

Otodus basalis (?), . . KIPRIJANOFF, V., 1854. "Bull. Soc. Imp. Nat. Moscou," pt. ii., p. 388, pl. II., figs. 31–38; pl. III., figs. 1–10.

Otodus appendiculatus, . . HEBERT, E., 1852. "Mém. Soc. Géol. France" [2], vol. v., p. 355.

Otodus appendiculatus, . .	FISCHER, C. E., 1856. "Allg. deutsche. Naturh. Zeit.," N.S., vol. ii., p. 141, pl. II., figs. 38–44, 59.
Otodus appendiculatus, . .	PICTET AND CAMPECHE, 1858. "Foss. Terr. Crétacé St. Croix," p. 82, pl. X., figs. 3, 4.
Otodus appendiculatus, . .	ROEMER, F., 1870. "Geol. von Oberschlesien," p. 323, pl. XXXVI., fig. 6.
Otodus appendiculatus, . .	SAUVAGE, H. E., 1872. "Bibl. Ecole Hautes Études," vol. v., No. 9, p. 26, pl. II., figs. 57–59.
Lamna acuminata, . .	SAUVAGE, H. E., 1872. "Bibl. Ecole Hautes Études," vol. v., No. 9, p. 34, pl. II., figs. 73–75.
Otodus appendiculatus, . .	ST. ZARECZNEGO, 1874. "Sprawozd. Komisyi Fizijograf. Galicyi," vol. viii., p. (125).
Otodus appendiculatus, . .	GEINITZ, H. B., 1875. "Palæontogr.," vol. XX., pt. i., p. 294, pl. LXV., figs. 6, 7; pt. ii., p. 208, pl. XXXVIII., figs. 37–54.
Otodus appendiculatus, . .	ST. ZARECZNEGO, 1878. *Loc. cit.*, vol. xii., p. (203).
Otodus appendiculatus, . .	ETHERIDGE, R., jun., 1888. "Proc. Linn. Soc. N. S. Wales" [2], vol. iii., p. 158, pl. IV., fig. 1.
Otodus appendiculatus, . .	NIKITIN, S., 1888. "Mém. Comité Géol.," vol. v., No. 2, p. 60, pl. v., figs. 3–5.
Lamna appendiculata, . .	WOODWARD, A. S., 1889. "Catal. Foss. Fishes in the Brit. Museum," pt. i., p. 393.

Teeth medium size; median cone of anterior teeth high, robust, in form of isosceles triangle; point slightly recurved outwards; height of large example 0·030 m.; breadth at base of cone 0·017 m.; outer coronal surface slightly convex or flat; median basal portion depressed, with or without grooves; inner coronal surface convex, smooth; lateral margins constitute a sharp cutting edge. Single pair of divergent lateral denticles broad, compressed, pointed; breadth of base, including lateral denticles, 0·030 m. Postero-lateral teeth as broad as long; median cone more or less triangular; lateral denticles larger comparitively than those of the front teeth. Root larger, with deep lateral prongs; external surface depressed and hollow; internal one prominently convex.

In the collection sent from the Zoological Museum at Copenhagen there are a large number of teeth from the Chalk of Faxe which undoubtedly belong to this species. Associated with them are still larger numbers without lateral denticles,

and for the most part without root. The latter do not present any character which will distinguish them from the median cusp of *Otodus appendiculatus*, Ag., but are so similar in size and form that there can be no other course but to include them, although without lateral denticles, in the same species. Had they been found dissociated from the undoubted teeth of Otodus they would have been considered as teeth of *Oxyrhina mantelli*, Ag.; and it may still be possible that more minute investigation in the strata at Faxe will prove that the latter is their proper location. The peculiar nature of the matrix, and the manner in which it is cemented together, renders the extraction of the fish-teeth in a perfect condition difficult; and the lateral portions, as well as the base of the tooth, are very likely to be broken away unless especial care is exercised.* Specimens to which the matrix is still attached, in nearly every instance exhibit one or both the lateral denticles *in situ;* but it is easy to conceive that if the tooth were extracted from the limestone the median large crown would be broken off without the lateral cones and base. If the teeth have been collected by operatives unskilled in this branch of palæontology, they would probably not exercise the care necessary to obtain the specimens perfect, and this may account for their present condition.

The teeth from Oretorp are smaller in size than those from the remaining localities, and in a very large proportion of them the root is broken off, the median cone alone remaining. A few, however, are more perfect, and the root and lateral denticles are preserved.

Sauvage ("Biblioth. des Hautes Études," vol. v., p. 27) doubts whether all the teeth figured by Agassiz ("Poiss. Foss.," vol. iii., pl. XXXII., figs. 1–25) should be included in the same species, and considers that several species are confounded together. Agassiz himself appears to have held the same opinion, and states that among the number of teeth figured there are several which differ from each other more than certain species which have been described as distinct. The teeth represented by figs. 19–25 were probably a distinct species; and doubt was expressed as to whether figs. 17 and 18 were not also different. If fig. 7 be eliminated along with fig. 9, the latter being possessed of two pairs of lateral denticles, and the former being more of the form of Odontaspis than that of Otodus, the remaining figures seem to possess closely related characters; and, when so curtailed, the larger number of specimens from the Swedish Cretaceous system falls naturally into association with this species. Mr. A. Smith Woodward records the occurrence of a tooth resembling the original of fig. 7 (Agassiz, *tom. cit.*) associated with a group of about twenty-five others in a block of chalk from

* The three specimens on the tablet in the collection of the Zoological Museum, No. 305, may be referred to as exhibiting the character here indicated.

the neighbourhood of Maidstone. In the same group is a small tooth which may possibly be regarded as the third tooth of the upper jaw, closely resembling a tooth assigned to *Lamna subulata* by H. G. Geinitz ("Palæontogr.," vol. xx., pt. ii., pl. xxxviii., fig. 31).

In the Swedish collections the most numerous specimens are obtained from Oppmanna, in the lower stage of the Senonian beds, characterized by the presence of *Actinocamax mammillatus*, and are now located in the Museum of the University of Lund. In the Danish collections the best locality is Faxe, the Chalk of that district yielding large numbers of teeth in a very beautiful state of preservation. Several of these have been selected for illustration. The University Zoological Museum possesses a series from the Saltholmkalk, which formed part of the original museum collected by King Christian VIII.

Associated with the teeth are vertebræ which in all probability belonged to the same genus.

Swedish.

Formation and Locality.—Étage Danien: Annetorp. Étage Sénonien II.: Oppmanna. Faxe Coralline Limestone; Oretorp; Balsberg. Sénonien I.: Kopinge; Kjuge.

Ex coll.—Geological Museum, University of Lund, from all the localities except Oretorp and Kopinge. The teeth from Oretorp and Kopinge are from the Riksmuseum, Stockholm.

Danish.

Formation and Locality.—Étage Danien: Skillingsbro'; Saltholm; Stevns; Herfölge; Hjern; Annetorp; Faxe; Terkild-Skov in Seland; Ignaberga, Scania.

Ex coll.—Mineralogical Museum and Zoological Museum of the University of Copenhagen.

Otodus limhamnensis, Davis, sp. nov.

(Pl. xli., figs. 12.)

The teeth which are included in this species are distinguished by the great strength and thickness of the crown, and by the large and prominent development of the root. The crown is 0·030 m. in height; the width of the base is 0·020 m.; a lateral extension of the root beyond the width of the crown increases

its width to 0·030 m., and enables it to support on each side a lateral denticle. The outer coronal surface is convex in the median and upper parts; the lower part is depressed and flat; a slight median ridge extends from the base one-third of the height; enamel smooth. The inner coronal surface is deeply convex, expanding outwards at the base, without folds or striations. Lateral margins trenchant, continuous with the lateral denticles; the base of the enamel rises in a gentle curve from each side to the centre on both the inner and outer surface. The lateral denticles are strong, convex on each surface, rather more so on the inner than the outer one; margin with a sharp edge; point inclined away from the crown. Root large and massive, laterally extending beyond the enamelled surface. The outer surface is depressed from the base of the crown; from the inner coronal surface the root projects very boldly, extending forward nearly horizontally, the diameter being 0·016 m. The inferior surface of the root is deeply concave in the middle, with lateral projections extending downwards at an acute angle.

The specimens referred to this species are from Limhamn, in the district of Malmå, in the Danien formation. They approach, on the one hand, *Otodus appendiculatus*, Agassiz, and on the other, *Otodus spathula*, Sauvage ("Bibl. Ecole Hautes Études," vol. v., No. 9, p. 32, pl. i., figs. 27–32). The latter is from the white chalk occurring at Villavard, in the Sarthe. The crown is similar in form to the species now described. The characteristic of the Sarthe species consists in the lateral cones being separated from the principal one; the enamel of the latter does not extend to the former. This feature separates it clearly from the Limhamn type, in which the lateral cones are connected by the continuity of the enamel with that of the crown; the downward projections of the root are also much deeper than in the examples described by Sauvage; and the root is altogether much thicker. The latter character serves also to distinguish the species from *O. appendiculatus*, Ag. The crown of the tooth is stronger and thicker, and more convex on both the inner and outer surfaces.

Formation and Locality.—Étage Danien: Linhamn, Skåne.

Ex coll.—Riksmuseum, Stockholm.

Otodus obliquus, Agassiz.

(Pl. xli., fig. 13.)

Dens squali, . . Brander, G., 1766. "Foss. Hautoniensia," pl. ix., fig. 115.
Otodus obliquus, . . Agassiz, L., 1843. "Poiss. Foss.," vol. iii., p. 267, pl. xxxi.; pl. xxxvi., figs. 22–27.
Otodus lanceolatus, . Agassis, L., 1843. "Poiss. Foss.," vol. iii., p. 269, pl. xxxvii., figs. 19–23.
Otodus obliquus, . . Giebel, C. G., 1848. "Fauna der Vorwelt. Fische," p. 355.
Otodus obliquus, . . Gibbes, R. W., 1849. "Journ. Nat. Science, Philad.," ser. 2, vol. i., p. 199, pl. xxvi., figs. 131–137.
Otodus obliquus, . . Dixon, F., 1850. "Foss. Sussex," p. 204, pl. x., figs. 32–35; pl. xv., fig. 11.
Otodus obliquus, . . Morris, J., 1854. "Cat. Brit. Foss.," p. 335.
Otodus obliquus, . . Dames, W., 1883. "Sitzungsb. k. Preuss. Akad. Wissen.," pt. i., p. 145, pl. iii., fig. 6.
Otodus obliquus, . . Geinitz, H. B., 1883. "Abh. Naturw. Ges. Isis, Dresden," p. 6, pl. i., figs. 12–18.
Carcharodon obliquus, . Noetling, F., 1885. "Abh. Geol. Specialk. Preussen u. Thüring. Staaten.," vol. vi., pt. iii., p. 84, pl. vi., figs. 4–6.
Otodus obliquus, . . Davis, J. W., 1888. "Trans. Roy. Dublin Soc.," ser. ii., vol. iv., p. 15, pl. vii., fig. 16.
Lamna (?) obliqua, . Woodward, A. S., 1889. "Cat. Foss. Fishes Brit. Mus.," pt. i., p. 404.

The tooth represented by the figure indicated above is the only one occurring in the collections examined. It is from the Zoological Museum of the University of Copenhagen, and was obtained from the Cretaceous formation at Rugaard, near Grenaa, in Jutland. The tooth is strong and robust; the crown is 0·03 m. in height; the width of the base of the crown is 0·033 m., of which one-third is occupied by the lateral denticles. The outer coronal surface is moderately convex and smooth; the inner face is well-rounded and also smooth. The lateral margins and apex thin out to a fine cutting edge. Lateral denticles, one on each side, are broad, smooth, and acuminate. The root is very thick; and on the inside the median portion forms a prominent and expanded boss; the outside retreats

from the base of the crown; the under surface is deeply concave, the lateral prongs extending and forming deep projections.

This tooth is indistinguishable from the teeth of *Otodus obliquus*, Ag., of the Red Crag of the Eastern Counties of England; and although not previously recorded from measures lower than the Tertiaries, there appears no alternative but to place it with this species. Its nearest relation amongst the Scandinavian fishes is with *Otodus appendiculatus*, Agass.; but from that species it is distinguished by the thickness and rounded form of the crown, and by the great inner extension of the root.

Formation and Locality.—Kridt formation: Rugaard, v. Grenaa, Jutland.

Ex coll.—Zoological Museum, University of Copenhagen.

VERTEBRÆ OF OTODUS.

(Pl. XL., figs. 25, 26, 27; pl. XLII., figs. 1, 2, 21.)

Vertebræ of this genus occur with considerable frequency; they vary in size, and probably belonged to more than one species. The larger examples measure 0·055 m. in diameter, and the smaller ones 0·015 m. The internal structure possesses the characteristics represented by Professor Carl Hasse * in the Plagiostomi asterospondyli, the calcifications between the anterior and posterior concave surfaces assuming a radiating or star-like arrangement in vertical section. The vertebræ of Otodus are classed with Ginglymostoma and Crossorhinus in the Scylliolamnidæ.

Formation and Locality.—Étage Danien: Faxe. Étage Sénonien: Kopinge, Ignaberga.

Ex coll.—Zoological Museum, University of Copenhagen; Geological Museum, University of Lund.

SERIES OF SMALL VERTEBRÆ.

(Pl. XL., figs. 28–32.)

A number of vertebræ occur in the collection from the Riksmuseum at Stockholm which have been found in the Chalk beds at Kopinge. They are in some instances beautifully preserved, and probably belong to some of the smaller genera of Lamnidæ.

Formation and Locality.—Étage Sénonien (zone with *Belemnites mucronatus*): Kopinge, in the district of Ystad.

Ex coll.—Riksmuseum, Stockholm.

* "Das natürliche System der Elasmobranchier auf Grundlage des Baues und der Entwicklung ihrer Wirbelsäule," p. 209, pl. XXVII., figs. 26, 39, 40. 1882.

Coprolite (?) Otodus.

(Pl. XL., fig. 33.)

The coprolite figured is from the Museum at Stockholm, and is the only example occurring in any of the collections. It closely resembles the coprolite of Macropoma, and similar objects found in the Cretaceous formation of Bohemia were identified by Reuss* as the coprolites of *Macropoma mantelli*, Ag. Fritsch † expresses his conviction that, so far as the specimens represented on pl. v., figs. 1–5, by Reuss, were concerned, they were the coprolites of a Selachian, and probably belonging to *Otodus appendiculatus*, Ag. Some of the coprolites exhibited peculiarities of form which could not be attributed to Macropoma; and, further, there was no evidence of the presence of Macropoma in the beds from which the coprolites were obtained. The Swedish and Danish Chalk offers a parallel case. Taken independently, it is probable that the coprolite now figured might be associated with Macropoma; but no evidence of the scales or bony skeleton of this genus has been found, and the absence of such evidence leads to the inference that the coprolite may, with a reasonable amount of probability, be referred to *Otodus appendiculatus*, the remains of which are abundant.

Formation and Locality.—Étage Sénonien: Faxe.

Ex coll.—Riksmuseum, Stockholm.

Genus. **Carcharodon.** MÜLLER AND HENLE, 1841. "Syst. Beschreib. Plagiostom.," p. 70.

Second dorsal fin and the anal very small. A pit at the root of the caudal fin, which has the lower lobe well developed; side of the tail with a keel. Teeth large, erect, compressed, triangular, without basal cavity, margin serrated.

* "Verstein. der Böhmischen Kreideformation," p. 11, pl. v., figs. 1–8; pl. IV., figs. 68–80. 1845.

† "Reptil. u. Fische der Böhmischen Kreideformation," p. 18. 1878.

Carcharodon rondeletii, MÜLLER AND HENLE.

(Pl. XLI., fig. 14.)

Carcharodon rondeletii, . .	MÜLLER AND HENLE, 1841. "Syst. Beschreib. Plagiostom.," p. 70.
Carcharodon sulcidens, . .	AGASSIZ, L., 1843. "Poiss. Foss.," vol. iii., p. 254, pl. XXX. *a*, figs. 3–7.
Carcharodon sulcidens, . .	GIBBES, R. W., 1848. "Journ. Acad. Nat. Sci. Philad.," ser. II., vol. i., p. 147, pl. XXI., figs. 52, 53.
Carcharodon sulcidens, . .	GEMMELLARO, G. G., 1857. "Atti. Acad. Gioenia Sci. Nat.," ser. II., vol. xiii., p. 308, pl. IV.*a*, figs, 5–7.
Carcharodon tornabene, . .	GEMMELLARO, G. G., 1857. *Tom. cit.*, p. 309, pl. I.*a*, fig. 12.
Carcharodon etruscus, . .	LAWLEY, R., 1881. "Studi comp. Pesci Foss. coi viventi gen. Carcharodon, Oxyrhina, e Galeocerdo.," p. 17, pls. II., III., V. (Carcharodon), pl. IV. (Carcharodon), fig. 2.
Carcharodon rondeletii, . .	WOODWARD, A. S., 1889. "Cat. Foss. Fishes in Brit. Museum," pt. i., p. 420.

A portion of a tooth, probably belonging to this species, has been found in the Chalk at Faxe, and is now in the collection of the Mineralogical Museum at the University of Copenhagen. A part of the specimen has been cut away, apparently for the purpose of making microscopical sections; the remaining part exhibits the left half of the crown and root. The crown is 0·03 m. in height; the length of the margin of the tooth, including the root, is 0·045 m. The crown is thin and compressed; the outer surface is slightly convex, almost flat, with the apex slightly curved outwards. The inner surface is convex. The crown is widely expanded, its breadth equalling its height. The margin is serrated; there is no evidence of lateral denticles. The root, like the crown, is compressed; spongy in structure. The inferior surface concave, and conforming in outline to the base of the crown.

This specimen agrees in all essential particulars with the specimens described by L. Agassiz as *Carcharodon sulcidens*, Ag., from the Tertiary strata of Italy.

These specimens, and others, have since been studied by R. Lawley, and the results of his investigations have shown that the species is the same as *C. rondeletii*, M. & H., which still exists in the tropical seas. Smith Woodward has accepted the views held by Lawley, and regards the Italian fossil fish remains as pertaining to the existing species. Should all these determinations prove correct, the occurrence of a representative of the existing species in the Chalk of Faxe will be interesting.

Formation and Locality.—Étage Danien (Nyera Kridt): Faxe.
Ex coll.—Mineralogical Museum, University of Copenhagen.

Genus. **Corax.** Agassiz. 1843. "Rech. sur les Poiss. Foss.," vol. iii., p. 224.

Known only by the teeth, and confined to the Cretaceous rocks. Small or medium size; compressed, and more or less triangular; mature specimens generally with uniform marginal serrations; in young examples the serrated edge is sometimes wanting. Root large, slightly hollow beneath.

They resemble to some extent the teeth of Galeus and Galeocerdo; but Agassiz has pointed out that they are readily distinguished by the microscopical structure of the teeth ("Poiss. Foss.," vol. iii., p. 224), which in this genus are solid, as in the Lamnidæ; whilst the teeth of Galeocerdo and Galeus agree with the remaining Carchariidæ in being hollow in the interior. Corax is readily distinguished from Galeus by the smooth anterior margin of the teeth of the latter; and those of Galeocerdo are very strongly crenulated on the basal extremity, whilst the serrations of the crown are comparatively feeble. The solidity of the structure of the teeth of Corax recalled to Agassiz the similarity to Notidanus, and M. Sauvage ("Biblioth. de l'École des Hautes Études," vol. v., No. ix., p. 39), after considering the superficial and microscopical relationship of Corax with Galeus and Notidanus was disposed to consider that structure was of greater importance than external form, and that, in a truly natural classification, Corax will be found to have a greater affinity with Notidanus. Corax, so far as is known, became extinct with the Cretaceous period, and it remains to be seen whether its descendants must be looked for amongst the Tertiary and existing Galeus and Galeocerdo or in the Notidanidæ.

Corax lindstromi, Davis, sp. nov.

(Pl. xlii., figs. 3–11.)

Teeth of medium size, varying much in height and breadth of crown, but all possessed of an arched anterior margin, extending far down, and enveloping the base or root, and a more or less deep indent of the posterior margin. A large example has a breadth across the base of the crown of 0·022 m.; the height of the crown on the external surface is 0·012 m., and on the internal one 0·009 m. The size varies to specimens having only one-third these measurements. The external surface of the crown is slightly convex in the median part, flat towards the margins; slight folds in the enamel rise from the base, and disappear higher on the crown. Internal surface convex, with delicate, broad folds near the base. Line dividing the crown from the base deeply arched upwards on internal surface, less so on the external one. Anterior margin boldly arched, and extending over the root. Posterior margin straight, or with a slightly sigmoidal curvature, on upper part; the lower part extends thence more or less horizontally, forming a deep indent, at an angle varying from a right-angle to one which is obtuse. The margins are uniformly and finely serrated over their whole length; the apex of the crown is acuminate, the root is large, equal in breadth to the crown, flat on the external surface, convex on the internal one, inferior surface slightly concave.

The study of the large series of specimens of the genus Corax in the British Museum has induced Mr. A. Smith Woodward to reduce the number of species to three, viz. *Corax pristodontus*, Ag., *C. falcatus*, Ag., and *C. affinis*, Ag. The last is a small species, the principal teeth of which have a much elevated, slender crown, with a notch on both the posterior and anterior margin, producing a broad posterior, and a narrow anterior denticle. *Corax falcatus* is medium sized; the crown is elevated, not so much so as in *C. affinis;* the anterior coronal margin is arched, but not so much as in the *Corax pristodontus;* the posterior coronal margin is more or less deeply notched, and the base of the enamel on the external surface is comparatively straight. *Corax pristodontus* has a very broad base, a large tooth, has little or no indentation on the posterior margin, and the anterior margin of the crown is prolonged for a considerable distance over the root; the base of the crown on the external surface being thus rendered much arched, a feature not very well exhibited in the specimens figured by Agassiz ("Poiss. Foss.," vol. iii., pl. xxvi., figs. 10–13). The teeth now described from the Lower Senonian strata of Ifö and Oretorp appear to occupy an intermediate position

between *Corax pristodontus* and *Corax falcatus.* They have a well-marked indentation, or notch, on the posterior margin, and at the same time exhibit a long, arched extension of the anterior margin over the root, and the base of the crown on the external surface is rounded. They may either be considered as a connecting link uniting the two species, or as an independent species.

M. Reuss ("Verst. der. Böhmischen Kreideform," 1845, pt. I., p. 3) has expressed the opinion that only one species of Corax existed during the Cretaceous era, to which he gave the name *C. heterodon,* including in it *C. kaupii*, *C. falcatus*, *C. appendiculatus*, and *C. affinis*, of Agassiz. M. Herbert ("Mémoires de la Soc. Gèol. de France," 1854, ser. II., vol. v., p. 353) arrived at a similar conclusion after a very careful study of a large number of specimens from the Chalk of Meudon and Cotentin, embracing all the variations between *Corax kaupii* and *C. pristodontus*, and he suggested the name *Corax pristodontus*, Ag., as being the earliest, under which all the others should be affiliated; whilst M. Pictet was led to remark (Pictet et Campiche, "Foss. Crétacé de Sainte Croix," 1858, ser. II., p. 80) that there was very small probability that so many and varied forms could be associated on the jaws of the same fish; and M. Sauvage says that it is not to be supposed that only a single species had lived in the Cretaceous seas from the epoch of the Gault to that of the Maestricht beds ("Biblioth de l'École des Hautes Études," 1872, vol. v., art. 9, p. 40).

In the midst of so many learned opinions, a clear and definite judgment on this difficult and intricate set of phenomena is impossible. There may be some hope that a complete dental series may be found which will exhibit the natural arrangement; but until this happens all classification must of necessity be provisional. Whilst recognizing the possibility that many of the specimens now supposed to represent separate species may ultimately be proved to have been associated in the same jaws, it may be advantageous to consider them as distinct until material shall be acquired which will render their determination certain.

Formation and Locality.—Étage Sénonien Superieur: Köpinge; Étage Sénonien Inferieur (zone with *Actinocamax mammillatus*, Nills.): Ifö; Oretorp; Ignaberga; Oppmanna; Balsberg.

Ex coll.—Riksmuseum, Stockholm; Geological Museum of the University of Lund.

Order.—HOLOCEPHALI.

Family.—EDAPHODONTIDÆ, OWEN.

Genus. Ischyodus, EGERTON.

Ischyodus brevirostris, NEWTON (Ag. MS.).

(Pl. XLII., figs. 12–15.)

Chimæra (Ischyodon) brevirostris,	AGASSIZ, L., 1843. "Poiss. Foss.," vol. iii., p. 344 (name only).
Ischyodus brevirostris, . .	EGERTON, P. DE M. GREY, 1843. "Proc. Geol. Soc.," vol. iv., p. 156 (name only).
Ischyodus brevirostris, . .	MORRIS, J., 1854. "Cat. Brit. Foss.," p. 330.
Ischyodus brevirostris, . .	NEWTON, E. T., 1876. "Quart. Journ. Geological Soc." vol. xxxii., p. 326, pl. XXI., figs. 1–5.
Ischyodus brevirostris, . .	NEWTON, E. T., 1878. "Chimæroid Fishes, Brit. Cret. Rocks (Mem. Geol. Survey)," p. 27, pl. IX.
Ischyodus brevirostris, . .	DAVIS, J. W., 1888. "Trans. Roy. Dubl. Soc.," 2nd ser., vol. iv., p. 42. pl. VII., figs. 10–13.

Several specimens of this Chimæroid occur in collections from the Lund University. Mostly they are in a fragmentary condition. The specimen (fig. 12) is an example of the left mandible, and the most perfect in the collection. The posterior part of the jaw is defective and broken; this is the case with all the specimens, and has been explained by Newton. As the anterior parts of the jaws are worn away, they are constantly pushed forward by the growth of new matter behind, and the posterior parts always growing, and consequently being imperfectly ossified, they are readily broken and damaged. The anterior margin and the sinuous indentations which characterize it can be inferred, though the margin is defective. The symphysial margin is slightly convex. The oval surface of the tooth is divided between raised portions of dentinal substance and

intermediate smooth hollows. The dentinal substance, which is considered by Newton to be the representative of teeth, is arranged in a series of lamellæ, or plates, near the anterior beak of the tooth; but the larger number of teeth further back are composed of small tubes, generally perpendicular to the surface, around which the dentinal substance is deposited. The large central tooth has this construction. The teeth vary considerably in outline in the several specimens, and the jaws also offer no small variety. Compared with the English Gault specimens, this one is longer from front to back in proportion to the breadth from the symphysis to the opposite margin. In this respect it also differs equally from the examples from the Amuri Bluff beds in New Zealand.

Some specimens of smaller size also occur in the collection at the Lund University; they are imperfect, and the specific characters not well preserved. The specimen represented by fig. 14 may be a part of the pre-maxilla, and the one forming the subject of fig. 15 the anterior portion of the mandible. The structure of both is open and porous; the external surface is hard, smooth, and somewhat polished; the inner surface presents a more or less granulated appearance, due probably to the calcification of the extremities of the tubes forming the dentinal surface.

Formation and Locality.—Étage Sénonien, No. 2: Oppmanna; Étage Sénonien, No. 1: Köpinge (figs. 12, 13). Sénonien (zone with *Actinocamax mammillatus*, Nills.): Ifö; Ignaberga (figs. 14, 15).

Ex coll.—Geological Museum of the University of Lund.

Order.—GANOÏDEI.

Family.—**PYCNODONTIDÆ.**

Genus. **Cœlodus**, Heckel. 1849. "Beiträge zur Kenntniss der Fossilen Fische Oesterreichs," pt. i., p. 202, pl. i., fig. 6.

Pycnodus, . . . Agassiz, L., 1843. (in part.) "Rech. sur les Poiss. Foss.," vol. ii., pt. ii., p. 183.

This genus is distinguished by the teeth being hollow in the centre of the crown (not due to attrition), and the elongated teeth being raised towards each

extremity. Teeth of the upper jaw in five rows; median row large, transversely elliptical, side rows with small roundish or oval teeth. Each ramus of lower jaw with three rows of teeth; outer row small and round; middle row somewhat larger, transversely oval; inner row large, very broad, but short, elliptical, smooth, faintly arched, or flat. Cutting-teeth chisel-shaped.

Zittel has reconstituted the genus Cœlodus ("Handbuch der Palæontologie," vol. iii., p. i., p. 249), and along with the species described by Heckel has included all those teeth previously described as species of Gyrodus and Pycnodus, possessing the characters given above, amongst others the types of a number of teeth occurring in the Swedish Cretaceous rocks, which Agassiz described as *Pycnodus subclavatus* from the Maestricht beds.

Cœlodus (*Pycnodus*) *subclavatus*, Agass.

(Pl. xlii., figs. 16–18.)

A number of teeth in the collections from Stockholm and Lund may be relegated to this genus. The largest tooth is slightly imperfect, one extremity being broken. The part preserved is 0·023 m. in length, and 0·007 m. in breadth; it is thick and massive; surface of the crown smooth; subclavate in outline. A slight fold of the enamel extends round the base of the crown. Under surface hollow and rough, for attachment to the jaw. Other specimens are smaller, having a length of 0·017 m.

A group of five teeth (fig. 17) from the right ramus of the lower jaw exhibits three large teeth from the inner row, and a portion of the fourth, and a smaller one from an outer row. They are attached to a portion of the jaw having the ordinary open, spongy texture.

Two small, round teeth, apparently belonging to the same species, have been found in the Faxe or Coralline limestone.

Formation and Locality.—Étage Sénonien Superieur: Köpinge. Étage Sénonien Inferieur: Ignaberga; Faxe, Coralline limestone.

Ex coll.—Riksmuseum, Stockholm; University Museum, Lund.

Sub-Class.—TELEOSTEI.

Order.—ACANTHOPTERYGII.

Family.—**BERYCIDÆ.**

Genus. **Hoplopteryx**, AGASSIZ. 1843. "Rech. sur les Poiss. Foss.," vol. iv., p. 131.

Body compressed, more or less oval in outline; abdominal cavity deep; head large in proportion to the size of the body; orbit large; opercular bones serrated; vertebral column strong; dorsal fin with five or six spinous rays, strong, and widely separated. Anal fin has three spinous rays, supported by a strong interspinous process, which reaches nearly to the vertebral column. Scales large, strongly connected, but not coarsely punctured. Lateral line begins on the abdominal surface, near the tail, and passes over the vertebral column forward. It consists of arrow-shaped scales (von der Marck).

This genus is distinguished by the spinous and soft rays of the dorsal fin being continuous without intermission; in this respect it is separated from the genera Holocentrum and Myripristis, in which the spinous and soft rays form two separate fins. Agassiz* founded the genus on specimens of fish from the Chalk of Westphalia, which he named *Hoplopteryx antiquus.* I have on a previous occasion shown that some of the species associated with the genus Beryx † belong to Hoplopteryx (*B. superbus*,‡ Ag.; *B. zippei*,§ Ag.; and *B. Syriacus*,‖ Pictet & H.), and Mr. A. Smith Woodward ¶ has since adduced sufficient evidence to prove that *Beryx lewesiensis*, Mantell (= *B. ornatus*, Agass.), should also be placed in the genus Hoplopteryx.

Hoplopteryx lundensis, DAVIS.

(Pl. XLIII., figs. 1–3.)

Several specimens of this species occur in the Lund Museum. The matrix is a soft friable chalk, and the fossilized remains partake very much of the same

* "Poiss. Foss.," vol. iv., p. 131, pl. XVII., figs. 6–8.

† "Foss. Fishes of the Chalk of Mt. Lebanon," Trans. Roy. Dubl. Soc., ser. II., vol. iii., p. 513.

‡ "Foss. Sussex," p. 372, pl. XXXVI., fig. 5.

§ "Rech. sur les Poisson Foss.," vol. iv., p. 120, pl. XV., fig. 2.

‖ "Nouv. rech. sur les Poiss. Foss. du Mt. Liban.," p. 28, pl. I., fig. 1.

¶ "Proc. Geol. Assoc.," vol. x., p. 327, and "Catalogue Brit. Foss. Vertebrata" (Woodward and Sherborn), p. 98.

character, so that where the specimens are not fragmentary, from the breaking of the chalk, they are in few instances well preserved. The one represented on the plate indicated above has a length from the snout to the base of the tail of 0·205 m., and the tail, which is not well represented on this or any of the other specimens, is about an additional 0·04 m., which makes a total length of 0·245 m. The greatest height, in front of the dorsal fin, is 0·065 m.; thence the body diminishes in height to the peduncle of the tail, which is about 0·025 m. in height. The form of the body is an elongated oval, the posterior part tapering more rapidly than the anterior.

The head has a length of 0·08 m., and the height is 0·06 m. behind the orbit. The mouth is large, with a wide gape. The pre-maxillary (*p. mx.*) is 0·025 m. in length, dilated in front, and triangular behind. It bears a large number of small, pointed, villiform teeth, slightly larger near the anterior extremity than those behind. The maxilla (*mx.*) is long, anteriorly slender, but largely expanded towards its distal extremity. It has no teeth. The anterior extremity of the maxilla is attached to the vomer, and in the specimen (fig. 2, *vom.*) the anterior portion of this bone is shown to bear teeth. The mandible (*mn.*) is large and of robust proportions; the dentary (*d*) bears teeth similar to those of the pre-maxilla. Its internal surface, exhibited by a fracture of the bone, is deeply channelled, for the accommodation of the Meckel's cartilage; the articular portion of the mandible is deep, and at its lower posterior extremity is a small bone which is probably the angular. Above this the articular portion terminates in a coronoid process, extending upwards, at right angles to the base. The orbit (*or.*) is large, and occupies a forward position above the posterior extremity of the jaws. The bones forming the orbit, except the pre-orbital (fig. 1, *p.-or.*) are not well defined; neither can the elements composing the frontal or occipital regions of the head be very clearly distinguished. The frontal bones are shown in the specimens represented by all the figures, and those forming the upper posterior portion of the head in figs. 1 and 2. The arrangement of the bones composing the opercular covering is exhibited by figs. 1 and 3. The operculum (*op.*) is large, with a triangular posterior margin; it was probably thin, and for this reason is not well-preserved. It enveloped a portion of the body covered with scales. The sub-operculum (*s.-op.*), attached to the lower extremity of the operculum, is a semi-triangular bone, with a rounded inferior margin. The pre-operculum (*p.-op.*), is best preserved in specimen fig. 3. It is a long bone, shaped like a boomerang, with a sharp inclination forward on the anterior margin, at about one-third of its height; the posterior margin is finely serrated. The inter-operculum (figs. 2 and 3, *i.-op.*) is an oblong bone, the upper margin concave, whilst the inferior one is convex; both this and the pre-operculum are thicker and stronger bones than the remaining components of the gill-covers. The head represented by fig. 3 exhibits

the position and sequence of the mandibulary suspensorium composed of the hyomandibular (*h*), the symplectic, the quadrate, and the metapterygoid, the latter connecting the suspensorium with the pterygoid and the entopterygoid. The hyomandibular (*hyo.*) is largely expanded in its upper portion; its lower portion is contracted and partially hidden by the pre-operculum; joined to the hyomandibular in descending series is the symplectic or mesotympanic (*sym.*), which connects with the quadrate (*qu.*), to which the lower jaw is attached. The metapterygoid (*mpt.*) is a large, flat bone filling the space between the hyomandibular, the symplectic, and the quadrate, and connects them with the pterygoid (*pt.*) and the entopterygoid (*ept.*). The pterygoid is joined at its anterior extremity to a bone, which increases in size forwards, and which is probably the palatine (*pal.*). Attached to this bone are numerous teeth similar to those of the pre-maxilla. The palatine is also exhibited by the specimen represented by fig. 2, and on this also small teeth may be distinguished. The branchiostegals are exhibited in fig. 1.; they are long, curved bones, tapering at the distal extremity to a point.

The spinal column consists of thirty vertebræ, of which sixteen are caudal. The vertebræ are large and robust, 0·007 m. in height under the anterior rays of the dorsal fin, and 0·006 m. in length. Large hæmal and neural spines, with forked bases, are attached to the vertebræ. Connected with the hæmal spines, inter-spinous bones support the anal fin; whilst more numerous inter-spinous bones connect the neural spines with, and support, the dorsal fin. The ribs are long, and of considerable strength. A short distance below the vertebral column the ribs are crossed by a series of stylets or epiplural bones 0·015 m. in length.

The dorsal fin commences immediately over the scapular arch, and extends a distance of 0·09 m. along the dorsal surface. It is separated from the caudal fin by a space of 0·03 m. The anterior portion of the fin consists of a series of spinous rays, ten in number; the sixth from the head is the largest, being 0·025 m. in length, those before and behind diminishing gradually in size; the most anterior ones are short, rudimentary rays. All the rays are thick and strong, sharply-pointed, and inclined, with a slight curvature, backwards. Eight or ten articulated rays succeed without intermission the spinous ones; they are longer than the spinous rays, and divided towards the distal extremity into filaments. The anal fin commences opposite the anterior rays of the soft part of the dorsal fin, and extends backwards to a length of about 0·04 m., and appears to be separated from the base of the caudal fin by 0·03 m.; but this part of the body is not well preserved. The anterior rays of the anal fin, apparently three in number, are spinous; the posterior one is longest, equally strong and similar in form to the spines of the dorsal fin. The anal fin spines are supported by strong inter-spinous rays, widely expanded at the distal extremity, where attached to the fin rays.

The articulated rays diminish in length posteriorly, and are divided by repeated bifurcations similar to those of the dorsal fin. The caudal fin is not well preserved in any of the specimens; the one figured on Plate XLIII. is the best. The lower lobe consists, apparently, of eight or nine strong articulated dichotomizing rays, connected with the vertebral column by a hypural bone, but their length cannot be determined; the upper lobe of the tail appears to have had a similar number of rays. The body of the fish is split down the middle, and consequently the pectoral fins are not exhibited, but their position may be indicated by a number of ridges showing through the scales almost midway between the dorsal and ventral surfaces. The ventral fin is supported from the scapular arch by a largely-expanded pubic bone. It is situated on the ventral surface, immediately under the posterior margin of the gill-cover. The anterior ray is spinous, with a length of 0·025 m., it is thick, and sharply-pointed. The number of fin-rays cannot be determined, but the fins were of large size.

The scales are of medium size, the height of those situated behind the gill-covers being 0·004 m. The posterior margin is circular, and slightly imbricated. The surface is ornamented with striations, running more or less parallel with the axis of the body. The direction of the lateral line (*lat.*) is indicated by series of foramina, which occur on alternate scales along the superior portion of the body.

This species is readily distinguished from any previously described by the number and position of the spinous rays of the dorsal fin, the number of vertebræ, together with the size of the scales. The scales of *Hoplopteryx zippei*, Agassiz, are not known; those of *H. syriacus*, P. & H., and *H. oblongus*, Davis, from the chalk of Mount Lebanon, are much larger than those of the Swedish fish; the scales of *H. superbus*, Dixon, are also large. In *H. syriacus* there are six spinous rays in the dorsal fin, and its anterior ray is inserted, after a considerable interval, behind the head. *H. zippei*, Ag., has five spinous rays, which are inserted immediately behind the occiput; the number of vertebræ is about two-thirds that of the species now described. *H. oblongus* is possessed of six or seven dorsal rays, and its vertebral column consists of thirty-two vertebræ.

Formation and Locality—Étage Danien (zone with *Anancites sulcatus*, Goldf.): Saltholm Limestone; Limhamn, Scania.

Ex coll.—Geological Museum, Lund University.

Hoplopteryx, sp.

(Pl. XLII., figs. 19, 20.)

A number of detached scales occur in the Lund Museum from the chalk of Limhamn. They have a transverse diameter of 0·025 m., and the length, antero-

posteriorly, is 0·018 m. The anterior margin is nearly straight, the upper and lower margins slightly convex, whilst the posterior one is more or less crenulated. The scales appear to have been very thin near the posterior margin, and consequently easily broken. Most of the specimens are imperfect. The surface is striated, the striations extending parallel with the upper and lower margin of the scale, whilst a second series radiate from the middle of the anterior surface of the scale, and extend to the posterior margin (fig. 19). Other scales are more or less oval in outline, with concentric rings over the greatest portion of the surface, the posterior part of the scale, which was uncovered by succeeding ones, being striated (fig. 20). The greatest diameter is 0·03 m.

These scales appear to resemble most closely those of *Hoplopteryx lewisiensis*, Mant. (*Beryx ornatus*, Ag.), and, whilst there is insufficient material to form a species, there can be no hesitation in including them in the genus Hoplopteryx.

Formation and Locality.—Étage Danien (zone with *Anancites sulcatus*, Goldf.): Saltholm Limestone; Limhamn, Scania.

Ex coll.—Geological Museum, Lund University.

Hoplopteryx minor, Davis.

(Pl. xlv., figs. 3 and 4.)

A number of specimens of a small species of Hoplopteryx from the chalk of Limhamn occur in the collections at the Riksmuseum at Stockholm. They are all imperfect, and afford only a small amount of information as to their characters and structure. The head, and a portion of the vertebral column, is all that is preserved. The head, from the tip of the snout to the posterior margin of the gill-cover, is 0·05 m., and the height of the head 0·04 m. The orbit was probably large. The gill-cover consists of the pre-operculum (*p. op.*), a long bone, with a crenulated margin; the operculum (*op.*) is imperfect, the anterior margin slightly concave, the upper margin rounded, and the remaining part along the posterior margin inclined to the inferior anterior extremity, so as to form an irregular triangle. The inter-operculum is not preserved; but a detached bone has the appearance of being the sub-operculum (*s. op.*). The mandible (*m.*) is attached at its posterior extremity to a triangular bone, the quadrate (*q.*). The mandible is strong, deep behind, the dentary portion bearing a number of small teeth. The maxilla (*mx.*) and pre-maxilla (*p.-mx.*) may also be distinguished, but the dentition of the latter is not defined. Other bones may be distinguished on the anti-orbital and inter-orbital regions of the head.

A portion of the vertebral column is preserved. It extends to a distance of

0·035 m. behind the occiput, and is 0·025 m. in length. The vertebræ are 0·005 m. in length, and a little less high than long.

The specimen represented by fig. 4 is in all probability a smaller example of the same species. A number of spinous rays are preserved on the dorsal surface. The anterior ray is located a distance behind the occiput, equal to the length of the head. The fin-rays are supported by inter-spinous bones. The ribs are long and moderately strong. A series of epiplural spines extend transversly to the ribs, parallel with, but separated a short distance from, the vertebral column.

This species does not agree with any of those previously described, as far as its imperfect remains can be deciphered.

Formation and Locality.—Étage Danien: Limhamn, Scania.

Ex coll.—Riksmuseum, Stockholm.

Genus. **Berycopsis.** Dixon.

This genus was proposed by Professor L. Agassiz for a fish from the Chalk of Sussex. It has much resemblance to the genus Beryx, but differs from it in the absence of pectinations on the free margins of the scales. The scales are of moderate size, thick, and smooth, or only ornamented with delicate radiating lines. The fin-rays of the dorsal and anal fins are robust. The rays of the dorsal fin are continuous with the preceding spinous rays, six or more in number, shorter than the soft rays, but stout and strong. Pelvic fin with a spinous ray, and seven or more articulated rays. Anal and caudal fins unknown.

The only species known is *B. elegans*, Dixon, from the middle chalk, Clayton, of which the type specimen is in the Brighton Museum. There are others in the Natural History Department of the British Museum, South Ken sington.

Berycopsis lindstromi, Davis.

(Pl. xliv., figs. 1, 1*a*.)

A large and unique specimen, which apparently belongs to this genus, occurs in the collection of the Geological Survey at Stockholm. The length of the part preserved is 0·23 m.; but the fish is devoid of the caudal fin, and the head is somewhat dislocated, and badly preserved. The body is deep, measuring 0·10 m. in front of the dorsal fin. The dorsal and anal fins are not preserved, except the remains of a single spinous ray of the dorsal; but the presence of a long dorsal fin is indicated by a long series of inter-spinous rays, which, no doubt, afforded

support to the fin. Judging from a similar analogy, the anal fin occupied a length much shorter than the dorsal, and was situated in close proximity to the caudal fin. The caudal fin was probably large and powerful, the bases of strong rays surrounding the extremity of the vertebral column affording evidence to that extent, though the fin itself is absent.

The front part of the body, with the head, is displaced, and this renders the identification of this part of the fish obscure. The operculum on the left side has been squeezed down, and with it the scapular bones supporting the pectoral fin. The pectoral fin, originally occupying a lateral position, is represented on this specimen depressed to a position on the ventral surface. It was large, and apparently composed of a large number of rays. A second fin is represented; it is of considerable size, and may be the ventral fin attached to the opposite side of the body.

The whole of the surface of the body is covered with scales; they are thin, closely overlapped, and of medium size; a few scales on the ventral surface are tolerably perfect; the exposed part is 0·004 m. in height; the posterior border is circular, with a minute imbrication, determined with difficulty by a strong magnifier, along the margin; the surface of the scale has a concentric arrangement of striæ, roughly parallel with the margin (fig. 1*a*). The anterior portion of the scale is hidden beneath the posterior margins of the preceding scales. The majority of the scales are crushed and imperfect. The vertebral column is distinctly visible beneath the scales, especially the posterior part. It consisted of about forty vertebræ, 0·05 m. in length; the height slightly exceeding the length in the median part of the body; nearer the tail the vertebræ are considerably shorter. They are less constricted in the median part than are the vertebræ of Hoplopteryx, and the articulating surfaces are supported by numerous buttresses, extending from one to the other. To the vertebræ are attached strong hæmal and neural spines, which in turn afford support to inter-hæmal and inter-neural spines. These can be readily distinguished beneath the scales. The ribs are comparatively long, reaching two-thirds the distance from the vertebrae to the abdominal margin.

This specimen is related to *Berycopsis elegans*, Dixon,* from the chalk of Sussex.

Formation and Locality.—Étage Danien (zone with *Anancites sulcatus*): Saltholm Limestone; Linhamn, Scania.

Ex coll.—Riksmuseum, Stockholm.

* "Geology and Fossils of Sussex," p. 372, pl. xxxv., fig. 8. 1850.

Family.—**TRICHIURIDÆ.**

Genus. **Enchodus.**

Enchodus, sp.

A small number of teeth, apparently belonging to the genus Enchodus, have been found in the Upper Senonian beds characterized by the presence of *Belemnites mucronatus* at Köpinge. The largest of the teeth is 0·015 m. in length, with a diameter at the base of 0·003 m. The surface of the teeth is finely and regularly striated longitudinally; the tooth is compressed, and a sharp edge is produced along each lateral margin. The teeth are broken off at the base, where they have probably been anchylosed with the jaw. Other specimens, two-thirds the size of the above, exhibit similar characters, one of them being especially well-developed along the lateral margins, which extend in a knife-like process on each side.

The teeth are probably those of *Enchodus halocyon*, Agassiz, (*lewisiensis*, Mantell) (" Poiss. Foss.," vol. v., pt. i., p. 64, pl. xxv. c., figs. 1–16); but there is scarcely sufficient preserved to satisfactorily determine the identity.

Formation and Locality.—Étage Sénonien Superieur; Köpinge.

Ex coll.—Riksmuseum, Stockholm.

Genus. **Bathysoma.** Gen. nov.

Body compressed and elevated; head large; snout prominent; scapular arch composed of bones of great length and thickness.

Bathysoma lutkeni, Davis.

(Pl. xlvi., figs. 1–7.)

A fine series of specimens from the Saltholm Limestone occur in the Museum of the University of Lund and in the Mineralogical Museum of the University of Copenhagen. They have all been obtained from Limhamn, in Scania. The fish is compressed laterally; it reaches a length of about 0·10 m., and the height of the body immediately behind the scapular arch is equal to four-fifths of the length; or, if the measurement be taken from the anterior extremity of the mandible to the peduncle of the tail, the height of the body is equal to the length.

The head is large, and absorbs quite two-fifths of the entire length. The facial contour forms a prominent feature. The body of the fish rapidly diminishes in size towards the tail. It is to be regretted that no specimen is sufficiently well preserved to exhibit the entire form of the fish; but a more or less complete idea can be obtained by comparing the several specimens, and taking the aggregate result. (Pl. XLVI., fig. 7.)

The head is produced anteriorly, and terminates in a protruding snout; the posterior margin, formed by the operculum and a thin median bone extending from the supra-occipital region forwards, is more or less circular in outline. The orbit is situated in the posterior moiety of the head, and is somewhat high; it is large and encircled by bones. In front of the orbit a large but thin bone may be distinguished, which represents the pre-orbital; its posterior boundary is formed by the margin of the pre-operculum. A straight bone, probably the para-sphenoid, extends across the base of the orbit. The maxilla is long and somewhat slender, and is divided by an oblique suture from the pre-maxillary. The mandible is large, high in front, diminishing in size backwards, and extending to a position beneath the orbit, where it is articulated with the quadrate. No teeth can be distinguished on any of the specimens, either on the upper or lower jaws. The inter-orbital bones are not well preserved on any of the examples; but fragmentary outlines exist which indicate that the frontal and occipital bones are produced, and form a thin median bony crest, extending above the orbit backwards. The operculum consists of four elements: the pre-operculum is a triangular bone, with a concave anterior margin, pointed above, and rounded below; deep ridges extend from the pointed upper margin, and radiate towards the circular inferior margin. Behind and above the pre-operculum is the operculum; it is rounded behind, and channels radiate over its surface from the upper anterior margin, where it joins to the pre-operculum. It is the largest of the opercular bones. The sub-operculum is a long bone, extending parallel with the operculum, and situated immediately behind it. The inter-operculum is also long and narrow, extending from the sub-operculum to the anterior extremity of the pre-operculum. Other bones of the head may be distinguished, but not with sufficient distinctness to be readily identified.

The vertebral column consists of thirty vertebræ, of which ten are abdominal, and the remainder caudal. The vertebræ nearest the head are equal in height to the length, but towards the tail they become gradually narrower, so that the height is greater than the length. The centra are biconcave, and the median external surface is much constricted. The apophyses of the vertebræ are strong and afford attachment to hæmal and neural spines, the former of great length. The upper part of the body is not in any instance well preserved; but the neural spines are seen to have an elevation of 0·02 m., and the fragmentary remains of

inter-neural spines are present. The hæmal spines are longer than the neural. Attached to them are inter-hæmal bones of great strength; their anterior and posterior margins are expanded, so that the series form an almost continuous bony mass. The anterior inter-hæmal bones are more numerous than the hæmal spines. There are two, and in the anterior part three, inter-hæmals to one hæmal. The first hæmal and inter-hæmal are very thick and strong, and are each of so great a length that they overlap to a considerable extent. The lower extremity of the inter-hæmal is widely expanded, and with a convex curvature extends forward to such an extent as to form an attachment with the styliform process of the post-clavicle and other elements of the scapular arch. With so strong a basis for support, it will naturally be inferred that the anal fin was large, with anterior spinous rays, but no trace of the actual fin remains on the specimens under examination. Nearer the caudal fin both the hæmal and neural spines and their auxiliaries become rapidly smaller. The caudal fin is attached by a short peduncle; the terminal vertebra supports an expanded triangular hypural bone, to which the rays of the tail are attached. Like the dorsal and anal fins, the caudal is not well preserved; but one specimen shows that the caudal was composed of numerous finely-articulated fin-rays. The ribs were short and attenuated.

The scapular arch exhibits a peculiar modification, adapting it to the great depth of the body. The upper members of the series are hidden by the overlying bones of the operculum. Immediately behind the extremity of the mandible, the clavicle extends with a gentle curvature backwards and downwards, and at its extremity joins a styliform process of the coracoid. Attached to these bones is the pubic, a large bone, widely expanded at the base, but tapering upwards to a pointed extremity. The clavicle is a strong bone, with an expansion of the upper surface. A very long and slender post-clavicle, its attachment at the upper end hidden by the gill-covers, descends in the form of a styliform process, and assists in giving support to the large pubic bone, to which the ventral fin was doubtless attached, but nothing remains to indicate its size or form.

Amongst existing fishes the Sun-fish, *Lampris luna*, is a pelagic fish, which attains to a great size; it is found commonly near Madeira, and from thence northwards in the Atlantic. Its skeleton exhibits a very large development of the scapular arch, and in many respects it closely resembles the fossil. The clavicle is very long and dilated, and the post-clavicle, slightly expanded at the top, descends in the form of a long styliform bone. Similar characters, but less distinctly specialized, may be observed in the skeleton of *Capros aper*, a Mediterranean fish, sometimes found on the coasts of England.

Some of the species of the fossil Gastronemus, most especially *G. rhombeus*, Ag.,*

* "Poissons Fossiles," vol. v., p. 20, pl. II., figs. 1, 2.

present some features of great similarity to the species now described. The body is elevated and compressed; the scapular arch large and well developed; ribs small and insignificant, and the inter-spinous bones large and expanded. The vertebral column is more massive and stronger in proportion to the size of the fish; it is composed of twenty-four vertebræ, whilst in the species now described there are thirty. Gastronemus occupies a position intermediate between the forms represented by Vomer* and the species now described, with a strong inclination towards Vomer. Both these genera have the same number and distribution of the vertebræ; but in this species the vertebral column is smaller and less robust, whilst the number of its constituents is larger. The pectoral fin is large in Vomer and Gastronemus, but in this genus is comparatively small. The greatest and most characteristic divergence will be found, however, in the character and composition of the elements of the scapular arch.

Formation and Locality.—Saltholm Limestone; Étage Danien (zone with *Anancites sulcatus*, Goldf.): Limhamn, Scania.

Ex coll.—University Mineralogical Museum, Copenhagen; University Geological Museum, Lund.

Order.—PHYSOSTOMI.

Family.—CLUPEIDÆ.

Genus. **Clupea**. Linn.

Body compressed, with the abdomen serrated, the serrature extending forwards to the thorax. Scales of moderate or large, rarely of small, size; upper jaw not projecting beyond the lower; cleft of the mouth of moderate width; teeth, if present, rudimentary and deciduous. Anal fin of moderate extent, with less than thirty rays; dorsal fin opposite to the ventrals; caudal forked.

Clupea lundgreni, Davis.

(Pl. xlv., fig. 5.)

A unique specimen of this genus occurs in the Museum of the University of Lund. It is unfortunately imperfect. The part of the body preserved includes

* "Poissons Foss.," vol. v., p. 28, pls. v. and vii.

the base of the caudal fin, the anal fin, a portion of the dorsal fin, and about forty vertebræ, of which sixteen are caudal. The length of the spinal column, which is preserved, is 0·09 m., and the total length of the fish, as indicated by this portion, was probably 0·15 m. The vertebræ are as high as broad, bi-concave, and much constricted medially. Each vertebra supports a hæmal and neural spine, long and slender, and as nearly as possible equal in length. Portions of the anal fin are preserved, but not sufficient to by so indicate precisely its form and size. The dorsal fin is represented by twelve fin-rays; the posterior rays are 0·05 m. in advance of the caudal fin. Opposite the anterior rays of the dorsal fin the ribs commence. They are strong and a considerable length. The tail is imperfect, only the base being preserved. No scales can be identified.

Formation and Locality.—Étage Danien: Saltholm Limestone; Limhamn.

Ex coll.—University Geological Museum, Lund.

Family.—**HOPLOPLEURIDÆ**, Pictet.

"Traité de Paléontologie," 2nd ed., vol. ii., p. 213.

"Body generally with four series of sub-angular scutes, and with intermediate scale-like smaller ones. One (?) dorsal only; head long, with jaws produced."

The family Hoplopleuridæ was established by Pictet for fishes which were devoid of scales properly so-called, but which are protected on the back and sides by rows of scutes. The head is long and the jaws provided with pointed teeth of unequal size. The bones of the head are frequently sculptured or granulose. The genera associated in this family by M. Pictet are Dercetis, Agassiz;* Sauroramphus, Heckel;† Eurypholis, Pictet;‡ Pelargorhynchus, Von der Marck;§ Leptotrachelus, Von der Marck;‖ Plintrophorus, Günther.¶ The fishes included in the genus Dercetis were considered by Agassiz to resemble the sturgeons in the arrangement of the dermal scutes, and were grouped amongst the Ganoids. Heckel held the same opinion with respect to the position of Sauro-

* "Poisson Fossiles." vol. ii., pt. ii., p. 258. 1843.

† "Beitr. zur Kennt. der. Foss. Fische Österreichs," p. 17. 1849.

‡ "Desc. Poiss. Foss. du Mt. Liban.," p. 28. 1850.

§ "Ueber einige Wirbelthiere, &c., der Westphälischen Kreide."—Zeitschr. deutsch. Geol. Ges., vol. x., p. 242. 1858.

‖ "Fossile Fische, Krebse und Pflanzen aus dem Plattenkalk der jüngsten Kreide in Westphalen."—Palæontographica, vol. ix., p. 61, pls. xi., xii., fig. 3. 1863.

¶ "Desc. of a New Foss. Fish from the Chalk."—Geol. Mag., vol. i., p. 114, pl. vi. 1864.

ramphus, and Von der Marck also places the genera Pelargorhynchus and Leptotrachelus amongst the Ganoids, but regards Ischyrocephalus as a Teleostean. A careful review of the whole of these genera, assisted by additional specimens of Leptotrachelus and Eurypholis discovered in the chalk of Mount Lebanon, convinced M. Pictet that they formed a group naturally associated, especially by the great analogy afforded by the peculiar arrangement of the series of scutes, and that they formed a family of the Teleosteans, to which he gave the above name.

Genus. **Dercetis.** Agassiz, "Rech. sur les Poissons Fossiles," vol. ii., pt. ii., p. 258, pl. lxvi. *a*, figs. 1, 2, 5, 6, 7, 8 (*non* figs. 3, 4).

Syn.—Leptotrachelus, . . V. de Marck, 1863–64. "Fossile Fische, Krebse und Pflanzen aus dem Plattenkalk der jüngsten Kreide in Westphalen."—Palæontographica, vol. xi., p. 59.

Leptotrachelus, . . Pictet et Humbert, 1866. "Nouv. Rech s. les Poissons Fossiles du Mount Liban.," p. 93.

Leptotrachelus, . . Davis, 1887. "On the Fossil Fishes of the Chalk of Mt. Lebanon."—Trans. Roy. Dub. Soc., ser. ii., vol. iii., p. 619.

The genus Dercetis was instituted by M. Agassiz, in concert with Count Münster, for fossil fishes, with elongated body and head, the latter prolonged into a straight beak. The upper jaw a little longer than the lower, both being armed with elevated conical teeth, alternating with others smaller. The spinal column composed of robust vertebræ, longer than high, and constricted in the middle. Pectoral fins large, the ventrals small and composed of few rays. The dorsal fin is described as extending along nearly the whole surface of the back, the anal being about half the length of the dorsal, and finishing at the same point. The caudal short and slightly forked. The sides of the body are furnished with three rows of scutes, extending the whole length, and resembling those of the sturgeon. The scutes are heart-shaped, osseous, with a granular external surface, and surmounted by an angular median projection. The species described as pertaining to this genus are *D. elongatus*, Ag., from the chalk of Lewes, England, and *D. scutatus*, Münst. and Ag., from the Chalk of Westphalia. Mr. A Smith Woodward * has already pointed out that the English specimens are entirely devoid of fins; and it may consequently be presumed that the description of the long dorsal and anal fins was taken from the Westphalian species. It may further be inferred,

* "Proc. Geol. Assoc.," vol. x., p. 318. 1888.

that such being the case, the specimens were identical with those found in the same strata, which have since been described by W. Von der Marck under the generic name of Pelargorhynchus, which possesses a very long dorsal fin, and an anal similar to the one described by Agassiz.

In 1850, F. J. Pictet described three species of Dercetis from the Chalk of Mount Lebanon. Two of these, namely, *D. triqueter* and *D. tenuis*, were subsequently transferred in the "Nouvelles Recherches sur les Poissons Fossiles du Mont. Liban." (1866), to the genus Leptotrachelus, Von der Marck; and the addition of specimens in a better state of preservation proved that the *D. tenuis* was derived from the cervical region of *D. triqueter*. The third species *Dercetis linguifer*, Pictet, known only from a fragment of the body, very imperfectly preserved, was still doubtfully retained as representing the genus Dercetis in the Chalk of Lebanon.

In the description of the fossil fishes of Mount Lebanon * published in 1887, it is remarked that since the year 1866 a considerable number of specimens of Leptotrachelus have been obtained, and these differ much in size as well as in the details of the form of the scutes; and there can be no doubt that the figure given by M. Pictet (*op. cit.*, pl. IX., figs. 7, 8) is that of a portion of the body of a large fish of the genus Leptotrachelus, and that it is the same species as those already included in the species *L. triqueter*, Pictet and Humbert. Since the above was written I have had opportunities of examining the originals, in the Mantell collection at the British Museum (Natural History Department), figured by Professor Agassiz, and I am convinced that they are the same genus as the fish-remains described as Leptotrachelus from Mount Lebanon.† This being so, it becomes a question of synonomy, and as Dercetis was established about twenty years before Leptotrachelus, it follows that the latter must be considered as a synonym of Dercetis, Agass. The Lebanon fish-remains included under *Leptotrachelus triqueter*, Pictet and Humbert, will revert to the original designation of Pictet, and be again *Dercetis triqueter* (including *D. tenuis*, Pictet, and *D. linguifer*, Pictet), and the species *Leptotrachelus hakelensis*,‡ Pictet and Humbert, and *L. gracilis*,§ Davis, will be *Dercetis hakelensis* and *D. gracilis*.

Dr. Anton Fritsch describes specimens from the chalk of Wehlowitzer Pläner, near Prague, which he has named *Dercetis reussii*,|| Fritsch. The remains are

* "Trans. Roy. Dublin Soc.," ser. II., vol. iii., p. 619.

† *See* A. Smith Woodward "On Fossils of the English Chalk."—Proc. Geol. Assoc., vol. x., p. 319. 1888.

‡ "Nouv. Rech. s. les Poiss. Foss. du. Mt. Liban.," p. 98, pl. XIV., fig. 3. 1866.

§ "Trans. Roy. Dublin Soc.," ser. II., vol. iii., p. 623, pl. XXXVIII., fig. 3. 1887.

|| "Die Reptilien und Fische der Böhmischen Kreideformation," p. 20, pl. II., fig. 8; pl. IV., fig. 1; pl. X., figs. 1, 6. 1878.

fragmentary, consisting of the head and portions of the vertebræ, imperfectly preserved. They do not present sufficiently characteristic features for full comparison with the species already, or presently to be, described.

For the opportunity of studying the specimens which I now proceed to describe I am indebted to the courtesy and kindness of Dr. W. Dames of Berlin, to whom Dr. Lundgren had entrusted them, along with others, for description, previously to my visit to the Lund Museum. In order to render this memoir as complete as possible, Dr. Dames readily consented to place the fish-remains at my disposal, retaining the bird-remains which form the new genus Scaniornis, Dames.*

Dercetis limhamnensis, Davis.

(Pl. xlv., figs. 1, 2.)

Portions of this fish of large size have been found in the Faxe Chalk. The matrix is so soft and friable that the specimens, being of the same character, are not well preserved. The head and a part of the vertebral column is preserved, and parallel with the vertebræ are a number of scutes. The entire length of the head, from the snout to the posterior margin of the operculum, was probably 0·10 m. This portion of the body is succeeded by eighteen vertebræ, which occupy a length of 0.10 m. Compared with other species of the same genus, the parts preserved appear to indicate a fish having a total length of about a metre. There is no evidence of fins preserved.

The head is divided on the matrix from side to side in a plane parallel with the crown. The bones were thick and massive, but are so fractured that it is almost impossible to identify them. The position of the orbits, owing to the manner in which the head is divided, cannot be determined with certainty, but the depression at the side of the head may indicate its position (fig. 1., or fig. 2). The operculi have entirely disappeared. The bones of the cranium were thick and strong, and an impression remains on fig. 2 which exhibits the form of the occipital part of the skull.

The mandibles are articulated at a point quite under the posterior extremity of the skull, their length being 0·06 m. The dentary bone occupies a little more than half the length. A number of small setiform teeth, with acuminate apices, cover the upturned alveolar surface of the left mandible. Other strong bones running parallel to the mandibles may indicate the maxillæ; but if so, they are not sufficiently distinct to allow of description. A strong sigmoidally-curved bone,

* "Ueber Vogelreste aus dem Saltholmskalk von Limhamn bei Malmö."—Bihang till k. Svenska Vet.-Akad. Handlingar, Band 16, afd. iv., No. 1.

0·035 m. in length, extends between the occipital and the anterior vertebræ, and represents the scapular bones (*sc.*). The operculum probably occupied this area, but has entirely disappeared, unless the fine bone (*op.*) be a transverse section of it.

The spinal column is represented by eighteen vertebræ. A space between the head and the first vertebra preserved forms an interval requiring six or seven vertebræ to fill it. The vertebræ are 0·005 m. in length and 0·006 m. in height, in this respect differing much from those of *Derectis* (*Leptotrachelus*) *triqueter*, Pict. & Humb., from Mount Lebanon, in which the vertebræ near the head are twice as long as high. The vertebræ are constricted in the middle, and well ossified. (Pl. xlv., fig. 1 *c.*)

The scutes have, at least, two forms; one represented by fig. 1 *a* is probably from the median lateral line; the front consists of a pointed prolongation of the median axis; on each side are aliform expansions of the surface, whilst the posterior margin is made up of a pair of projections, one on each side the median line of the scute. The pointed prolongation of this scute may have been perforated by the canal of the lateral line. Mr. A. Smith Woodward has figured an example of a scute of *Dercetis elongatus*, Agass.,* from a flint-nodule found in the Chalk of Norfolk, England, which exhibits this peculiarity very beautifully. A second form on the specimen from Limhamn is represented by fig. 1 *b*, and is from the dorsal surface; it varies considerably from the lateral scute, and, so far as can be observed, extends from the median dorsal line, with the point towards the lateral line, a corresponding scute opposing it, and extending in the opposite direction. The two series of opposing scutes in the example figured may be seen to some extent enveloping the vertebral column, and extending from it on each side, with the point outwards.

The form and character of the scutes, together with the vertebræ, separate this species from those previously described, and I indicate it specifically by the name of the district from which it was obtained.

Formation and Localities.—Étage Danien: Saltholm Limestone: Limhamn, near Malmö, in Schonen.

Ex coll.—Lund University Geological Museum.

* "Proc. Geol. Association," vol. x., p. 318, pl. i., fig. 7.

LIST OF SPECIES, WITH THE LOCALITIES IN WHICH THEY OCCUR.

NAME OF SPECIES.	SENONIEN. SUPERIEUR.			SENONIEN INFERIEUR.							DANIEN.															
	Kopinge.	Kjuge.	Rugaard.	Kristianstad District.	Ignaberga.	Sissebäch.	Calshamm.	Balsberg.	Ifo.	Oppmanna.	Saltholm.	Luneberg.	Rannstrüp.	Sogstor.	Grenaa, Jutland.	Stevns.	Herfölge.	Annetorp.	Oretorp.	Malmä Dist.	Hjern.	Malmström.	Stevns.	Torkild-Skov.	Limhamn.	Faxe.
Myliobatis, sp. (?)	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	?	..	..	..	..	..	..
Ptychodus decurrens, Agass.,	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	×	×	×	..	..	..	..	..	..
,, mammillaris, Agass.,	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	×	..	×	..	..	..	..	..	..
Notidanus microdon, Agass.,	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	×	×	×	×	×
,, dentatus, A. S. W.,	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	×
Scyllium planum, Davis,	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	×	..	..
Scapanorhynchus tenuis, Davis,	..	..	..	..	..	..	×	..	..	..	..	..	×	×	×	..	×	×	×	..	..	..	..	..	..	×
,, latus, Davis,	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	×	×	..	..	..	..	..	..	..
,, gracilis, Davis,	..	..	..	..	..	..	..	..	..	×	..	..	..	..	..	..	..	×	..	..	..	..	..	..	..	..
Odontaspis acuta, Davis,	..	..	..	..	..	..	..	..	..	×	..	×	..	..	..	..	..	×	..	..	..	..	×	..	..	×
,, acutissima, Agass.,	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	×
,, faxensis, Davis,	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	×
,, kopingensis, Davis,	×	..	..	..	..	..	..	..	..	..	×	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Oxyrhina mantelli, Agass.,	×	..	..	..	..	..	..	..	..	×	×	..	..	..	..	..	..	×	..	..	..	..	..	..	×	..
,, lundgreni, Davis,	×	..	..	..	..	..	..	..	..	×	×	..	..	..	..	..	..	..	..	..	..	..	..	..	×	×
,, zippei, Agass.,	..	..	..	..	..	..	..	..	..	×	..	..	..	..	..	..	..	..	×	..	..	..	..	..	..	..
,, conica, Davis,	×	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	×	..	..	..	..	..	..	..
Lamna elegans, Agass.,	..	×	..	×	..	×	..	..	×	×	×	..	..	..	..	..	..	×	..	×	..	..	..	..	×	×
,, incurva, Davis,	..	×	..	..	..	×	..	..	..	×	×	×	..	..	..	..	..	×	..	..	..	..	..	..	×	×

LIST OF SPECIES, WITH THE LOCALITIES IN WHICH THEY OCCUR—*continued.*

NAME OF SPECIES.	Senonien Superieur.			Senonien Inferieur.							Danien.															
	Kopinge.	Kjuge.	Rugaard.	Kristianstad District.	Ignaberga.	Sissebäch.	Calshamm.	Balsberg.	Ifo.	Oppmanna.	Saltholm.	Luneberg.	Rannstrüp.	Sogstor.	Grenaa, Jutland.	Stevns.	Herfölge.	Annetorp.	Oretorp.	Malmä Dist.	Hjern.	Malmström.	Stevns.	Terkild-Skov.	Limhamn.	Faxe.
Otodus appendiculatus, Davis,	×	×	..	..	×	..	..	×	..	×	×	..	..	..	..	×	×	×	×	..	×	..	×	×	..	×
,, limhamnensis, Davis,	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	×	..
,, obliquus, Agass.,	..	..	×	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Carcharodon rondeletti, M. & H.,	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	×
Corax lindstromi, Davis,	×	..	..	..	×	..	..	×	×	×	..	..	..	..	..	..	..	..	×	..	..	..	..	..	..	..
Ischyodus brevirostris, Newton,	×	..	..	..	×	..	..	..	×	×	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Cœlodus subclavatus, Agass.,	×	..	..	..	×	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Hoplopteryx lundensis, Davis,	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	×	..
,, sp. (?),	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	×	..
,, minor, Davis,	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	×	..
Berycopsis lindstromi, Davis,	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	×	..
Bathysoma lutkeni, Davis,	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	×	..
Enchodus, sp.,	×	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Clupea lundgreni, Davis,	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	×	..
Dercetis limhamnensis, Davis,	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	×	..

PLATE XXXVIII.

FOSSIL FISH OF THE CRETACEOUS FORMATIONS OF SCANDINAVIA.

EXPLANATION OF PLATE XXXVIII.

Figure

1, 2. *Ptychodus decurrens*, Agass.

1. Annetorp. *Ex coll.*—Riksmuseum, Stockholm.
2. Oretorp. *Ex coll.*— ,, ,,

3. *Ptychodus mammillaris*, Agass. 3*a*. Side view.

Annetorp. *Ex coll.*—Riksmuseum, Stockholm.

4–7. *Notidanus microdon*, Agass.

4, 5. Teeth of the upper jaw. 4*a*. Enlarged.
6, 7. Teeth from lower jaw. 6*a*. Enlarged.
4, 5, 6. Malmström. *Ex coll.*—Geological Museum, University, Lund.
7. Limhamn. *Ex coll.*—Riksmuseum, Stockholm.

8. *Notidanus dentatus*, Smith Woodw.

Faxe. *Ex coll.*—Zoological Museum, University, Copenhagen.

9. *Scyllium planum*, Davis, $\frac{4}{1}$.

Terkild-Skov. *Ex coll.*—Mineralogical Museum, University, Copenhagen.

10–13. *Scapanorhynchus tenuis*, Davis.

10. Tooth ; *a*. internal surface, enlarged $\frac{4}{1}$; *b*. side view.
11. Median tooth ; *a*. internal surface, enlarged $\frac{4}{1}$.
12. Posterior tooth, natural size.

Oretorp. *Ex coll.*—Riksmuseum, Stockholm.

14–17. *Scapanorhynchus latus*, Davis.

14. Anterior tooth ; *a*. external surface ; *b*. side view ; *c*. internal surface. Enlarged $\frac{2}{1}$.
15, 16, 17. Other specimens.

Oretorp. *Ex coll.*—Riksmuseum, Stockholm.

18–20. *Scapanorhynchus gracilis*, Davis.

18*a*. Internal surface ; *b*. side view ; *c*. external surface. Natural size.

Annetorp. *Ex coll.*—Geological Museum, University, Lund.

21–24. *Odontaspis acuta*, Davis. (All natural size.)

21. *a*. External surface ; *b*. side view ; *c*. Internal surface.
23. *a*. External surface ; *b*. side view.
21. Annetorp. *Ex coll.*—Geological Museum, University, Lund.
22. Oppmanna. *Ex coll.*— ,, ,, ,, ,,
23. Stevns. *Ex coll.*—Mineralogical Museum, University, Copenhagen.
24. Faxe. *Ex coll.*— ,, ,, ,, ,,

25. *Odontaspis acutissima*, Agass.

Faxe. *Ex coll.*—Mineralogical Museum, University, Copenhagen.

26. *Odontaspis faxensis*, Davis.

a. External surface ; *b*. side view ; *c*. internal surface.

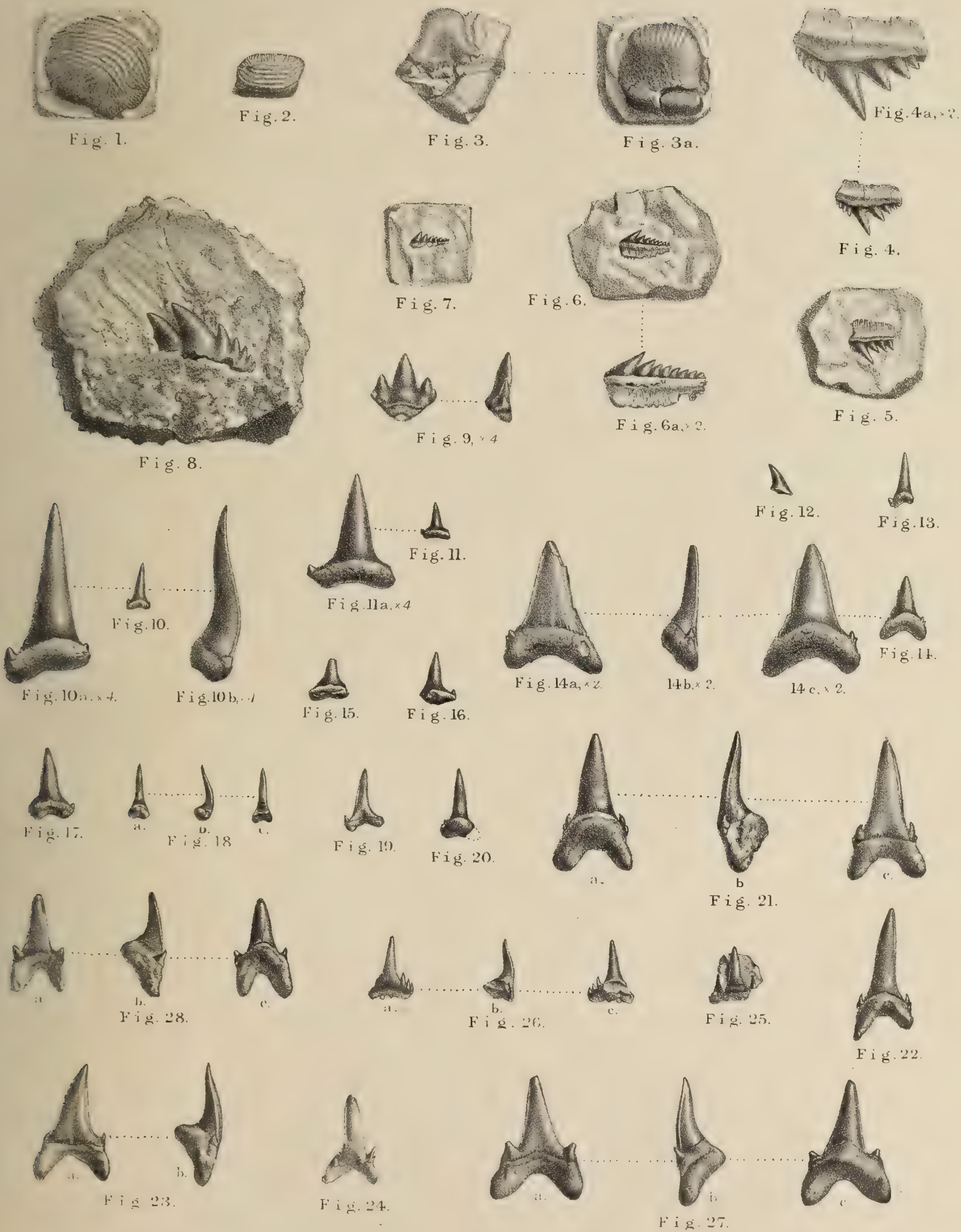
Faxe. *Ex coll.*—Mineralogical Museum, University, Copenhagen.

27, 28. *Odontaspis kopingensis*, Davis.

a. External surface ; *b*. side view ; *c*. internal surface.

27. Kopinge. *Ex coll.*—Mineralogical Museum, University, Copenhagen.
28. Saltholm. *Ex coll.*—Riksmuseum, Stockholm.

Plate XXXVIII.



J.W. Davis, Inr W.T. Crowther, del.

West Newman imp.

PLATE XXXIX.

FOSSIL FISH OF THE CRETACEOUS FORMATIONS OF SCANDINAVIA.

EXPLANATION OF PLATE XXXIX.

Figure.

1–7. *Oxyrhina mantelli,* Agass.

1. *a.* External surface of a median tooth ; *b.* side view ; *c.* internal surface.
1–5. Oppmanna. *Ex coll.*—Geological Museum, University, Lund.
6, 7. Limhamn. *Ex coll.*—Riksmuseum, Stockholm.

8–13. *Oxyrhina lundgreni,* Davis.

8. Anterior tooth, external surface.
9. Anterior tooth, with the root attached, external surface.
10. Highly-curved example, external face ; *a.* side view.
11. *a.* External surface ; *b.* side view ; *c.* internal surface.
8. Limhamn, Skanie. *Ex coll.*—Riksmuseum, Stockholm.
9. Faxe. *Ex coll.*—Mineralogical Museum, University, Copenhagen.
10, 13. Oppmanna. *Ex coll.*—Geological Museum, University, Lund.
11. Limhamn. *Ex coll.*—Riksmuseum, Stockholm.
12. ,, ,, ,, ,,

14. *Vertebra of Oxyrhina,* sp.

14 *a.* Side view of the same specimen.


a
b.
c.
Fig. 1.
Fig. 2.
Fig. 3.
Fig. 4.
Fig. 5.
Fig. 7.
Fig. 6.
Fig. 8.
Fig. 9.
10a.
Fig. 12.
Fig. 13.
Fig. 10.
a.
b.
c.
Fig. 11.
Fig. 14a.
Fig. 14.

PLATE XL.

FOSSIL FISH OF THE CRETACEOUS FORMATIONS OF SCANDINAVIA.

EXPLANATION OF PLATE XL.

Figure.

1–7. *Oxyrhina zippei*, Agass.

1*a*. External surface ; *b*. side view ; *c*. internal surface.
1–4. Oppmanna. *Ex coll.*—Geological Museum, University, Lund.
5–7. Oretorp. *Ex coll.*—Riksmuseum, Stockholm.

8, 9, 10. *Oxyrhina conica*, Davis, sp. nov.

8*a*. External surface ; *b*. side view ; *c*. internal surface. All × 3 diameters.
9. Posterior tooth.
10. Median tooth.
Oretorp. *Ex coll.*—Riksmuseum, Stockholm.

11–17. *Lamna elegans*, Agass.

11. Anterior tooth ; *a*. external surface ; *b*. internal surface.
12. Side view of anterior tooth.
13*a*. External surface ; *b*. internal surface. With lateral denticles.
14. External surface, with lateral denticle of median tooth.
15, 16. Posterior teeth.
17*a*. External surface ; *b*. side view ; *c*. internal surface.
Oppmanna. *Ex coll.*—Geological Museum, University, Lund.

18–24. *Lamna incurva*, Davis.

18*a*. External surface ; *b*. side view ; *c*. internal surface.
19, 20, 22. External surface.
21, 23. Internal surface.
24*a*. External surface ; *b*. side view ; *c*. internal surface.
18–23. Oppmanna. *Ex coll.*—Geological Museum, University, Lund.
24. Annetorp. *Ex coll.*— ,, ,, ,, ,,

25. *Vertebra of Otodus*, transverse section.
26. ,, ,, ,, ,,
Faxe Limestone. *Ex coll.*—Geological Museum, University, Lund.

27. *Vertebra of Otodus*, sp.

a. Concave surface of centrum ; *b*. lateral surface.
Ignaberga. *Ex coll.*—Geological Museum, University, Lund.

28–32. *Series of Small Vertebræ.*

a. Centrum Enlarged ; *b*. lateral views enlarged.
Köpinge. *Ex coll.*—Riksmuseum, Stockholm.

33. *Coprolite of Otodus.*

Köpinge. *Ex coll.*—Riksmuseum, Stockholm.

T W Davis, dir W H Crowther, del

West, Newman imp

PLATE XLI.

FOSSIL FISH OF THE CRETACEOUS FORMATIONS OF SCANDINAVIA.

EXPLANATION OF PLATE XLI.

Figure.

1–11. *Otodus appendiculatus*, Agass.

1. Anterior tooth; *a*. external surface; *b*. side view; *c*. internal surface.
2–6. Common forms of the teeth.
7, 8. Median teeth.
9–11. Posterior teeth.
1. Oppmanna. *Ex coll.*—Geological Museum, University, Lund.
2, 3, 4, 5. Faxe. *Ex coll.*—Mineralogical Museum, University, Copenhagen,
6. Faxe. *Ex coll.*—Zoological Museum, University, Copenhagen.
7, 8, 9. Faxe. *Ex coll.*—Mineralogical Museum, University, Copenhagen.
10. Annetorp. *Ex coll.*—Geological Museum, University, Lund.
11. Saltholm. *Ex coll.*—Collection of King Christian VIII., Copenhagen.

12. *Otodus limhamnensis*, Davis.

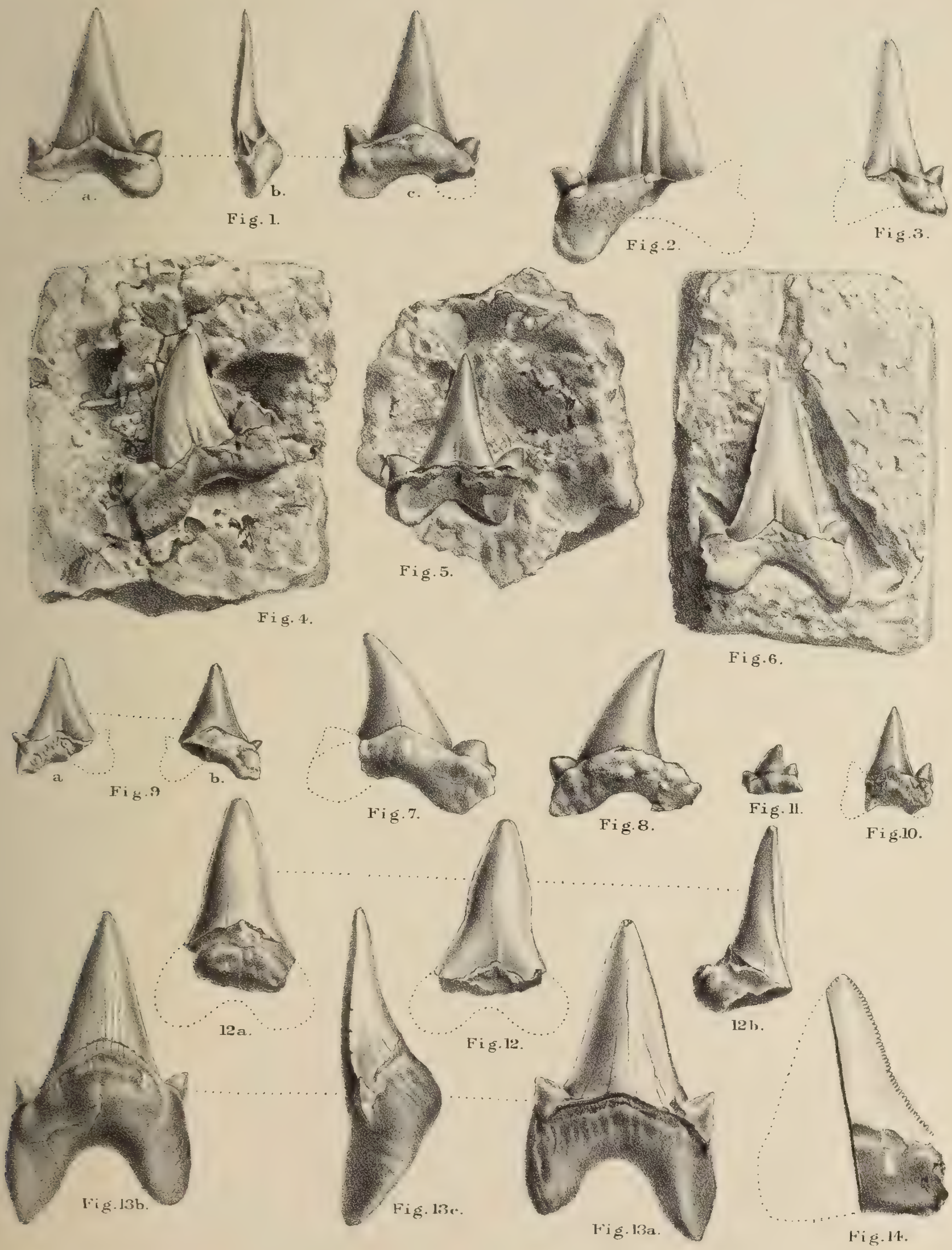
1*a*. External; *b*. internal surface; *c*. side view.
Limhamn, Scånia. *Ex coll.*—Riksmuseum, Stockholm.

13. *Otodus obliquus*, Agass.

13*a*. External surface; *b*. internal surface; *c*. side view.
Rugaard v. Grenaa, Steenberg. *Ex coll.*—Zoological Museum, University, Copenhagen.

14. *Carcharodon rondeletti*, Mull. and Henle.

Faxe. *Ex coll.*—Mineralogical Museum, University, Copenhagen.



T. W. Davis dir. W. H. Crowther, del.

West, Newman, imp.

PLATE XLII.

FOSSIL FISH OF THE CRETACEOUS FORMATIONS OF SCANDINAVIA.

EXPLANATION OF PLATE XLII.

Figure.

1. *Section of Vertebra of Otodus*, sp.

2. ,, ,, ,,

Faxe. *Ex coll.*—Zoological Museum, University, Copenhagen.

3–11. *Corax lindstromi*, Davis. *a.* External surface; *b.* internal surface.

3, 4. Oppmanna. *Ex coll.*—Geological Museum, University, Lund.
5–11. Ignaberga. *Ex coll.*— ,, ,, ,, ,,

12, 13. *Ischyodus brevirostris*, Newton.

12. Oppmanna. *Ex coll.*—Geological Museum, University, Lund.
13. Köpinge. *Ex coll.*— ,, ,, ,, ,,

14. *Ischyodus brevirostris*, Newton. Left pre-maxilla.

Ignaberga. *Ex coll.*—Geological Museum, University, Lund.

15. *Ischyodus brevirostris*, Newton. Mandible.

Ifo. *Ex coll.*—Geological Museum, University, Lund.

16–18. *Cœlodus subclavatus*, Ag.

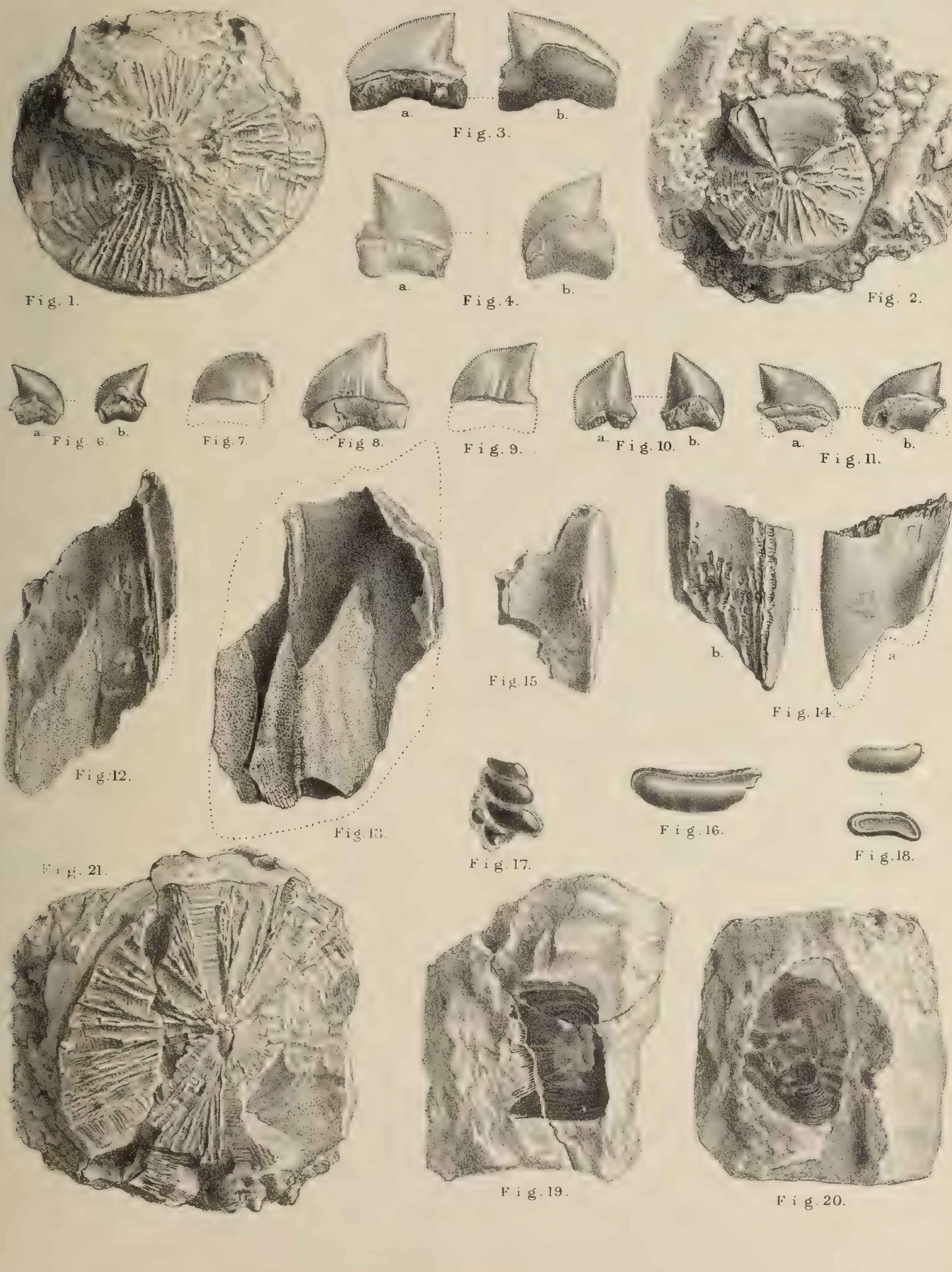
16, 18. *Ex coll.*—Riksmuseum, Stockholm.
17. Ignaberga. *Ex coll.*—Geological Museum, University, Lund.

19, 20. *Hoplopteryx*, sp.

Limhamn. *Ex coll.*—Geological Museum, University, Lund.

21. *Vertebra of Otodus.*

Faxe. *Ex coll.*—Mineralogical Museum, University, Copenhagen.



J W Davis, dir. W H Crowther, del

West, Newman imp

PLATE XLIII.

FOSSIL FISH OF THE CRETACEOUS FORMATIONS OF SCANDINAVIA.

EXPLANATION OF PLATE XLIII.

Figure.

1–3. *Hoplopteryx lundensis*, Davis.

Or. orbit, *p. or.* pre-orbital, *p. sph.* parasphenoid, *pt.* pterygoid, *e. pt.* entopterygoid, *hyo.* hyomandibular. *mpt.* metapterygoid, *sym.* symplectic, *quad.* quadrate, *op.* operculum, *p. op.* pre-operculum, *s. op.* sub-operculum, *i. op.* inter-operculum, *mx.* maxilla, *p. mx.* pre-maxilla, *m.* mandible, *dent.* dentary, *vom.* vomer, *tur.* turbinal, *fr.* frontal.

Limhamn. *Ex coll.*—Geological Museum, University, Lund.

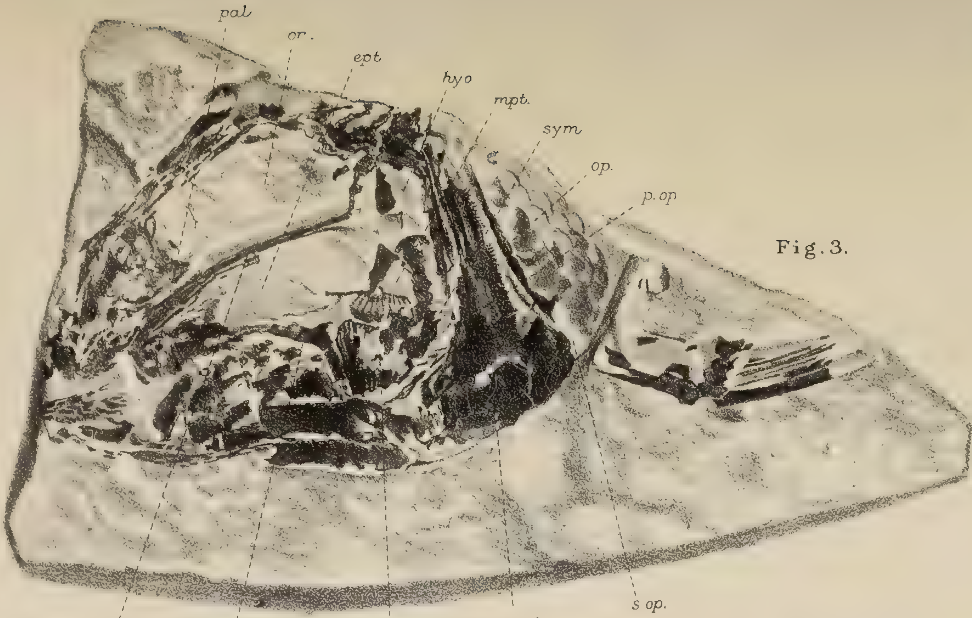


Fig. 3.

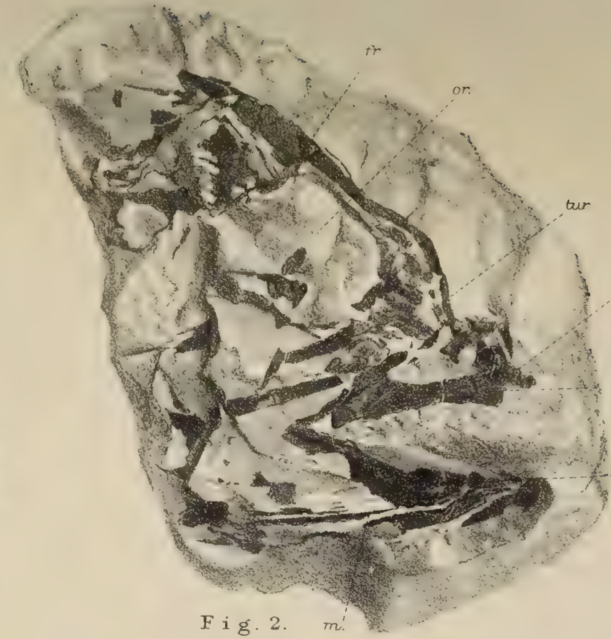


Fig. 2.

Fig. 1.

W. Davis, Dr. W. H. Crowther, del.

West, Newman imp.

PLATE XLIV.

FOSSIL FISH OF THE CRETACEOUS FORMATIONS OF SCANDINAVIA.

EXPLANATION OF PLATE XLIV.

Figure.

1. *Berycopsis lindstromi*, Davis.

1*a.* Scale from the ventral surface enlarged.

Ex coll.—Riksmuseum, Stockholm.

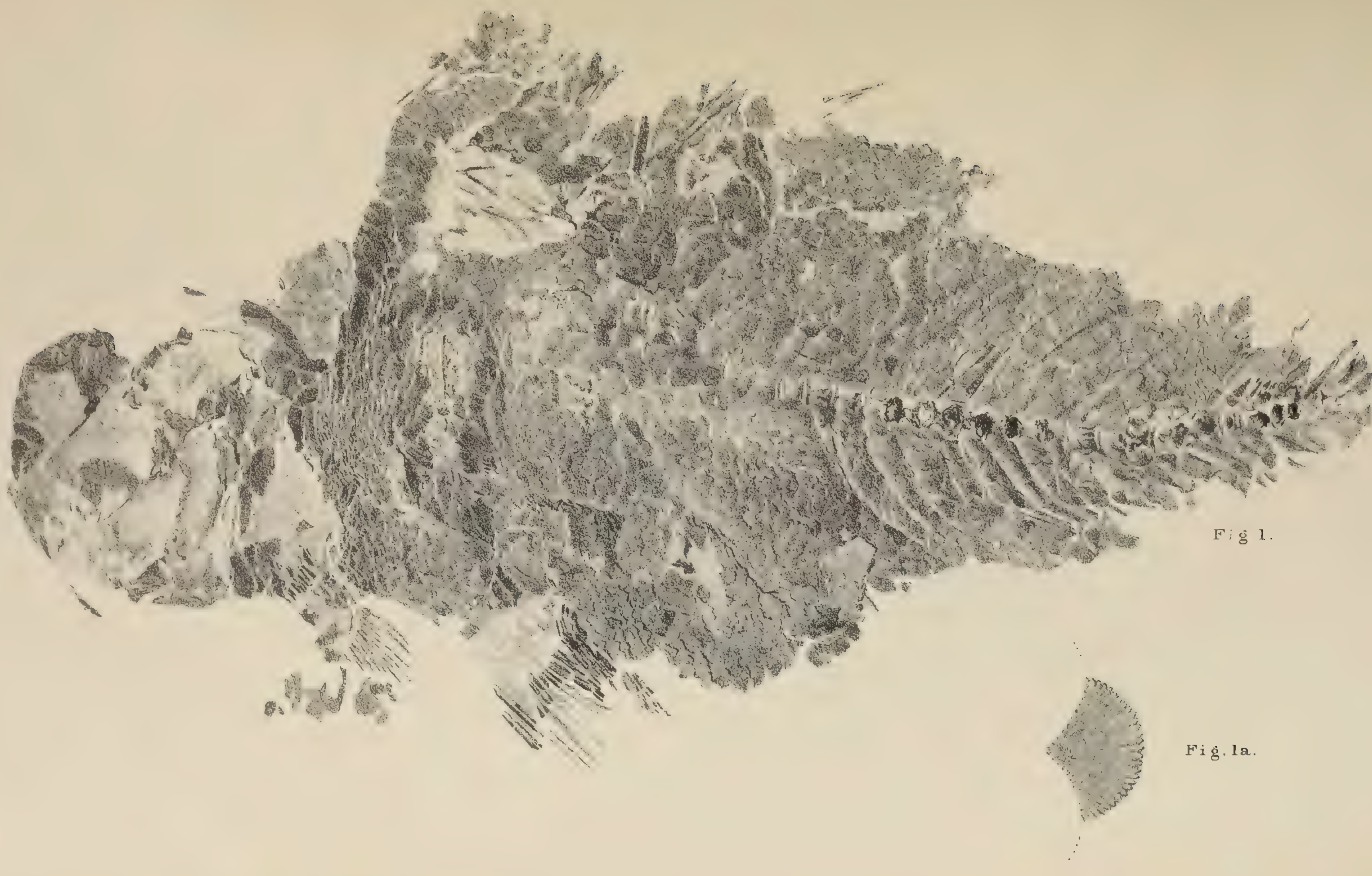


Fig 1.

Fig. 1a.

J.W. Davis dir W.H. Crowther del

West, Newman imp

PLATE XLV.

FOSSIL FISH OF THE CRETACEOUS FORMATIONS OF SCANDINAVIA.

EXPLANAEION OF PLATE XLV.

Figure.

1. *Dercetis limhamnensis*, Davis.

    1*a*. Lateral scute enlarged two diameters.

    1*b*. Scute from dorsal surface, enlarged two diameters.

    1*c*. Vertebræ enlarged.

2. *Dercetis limhamnensis*, Davis. Head of the same specimen, exhibiting the occipital arrangement of head-bones.

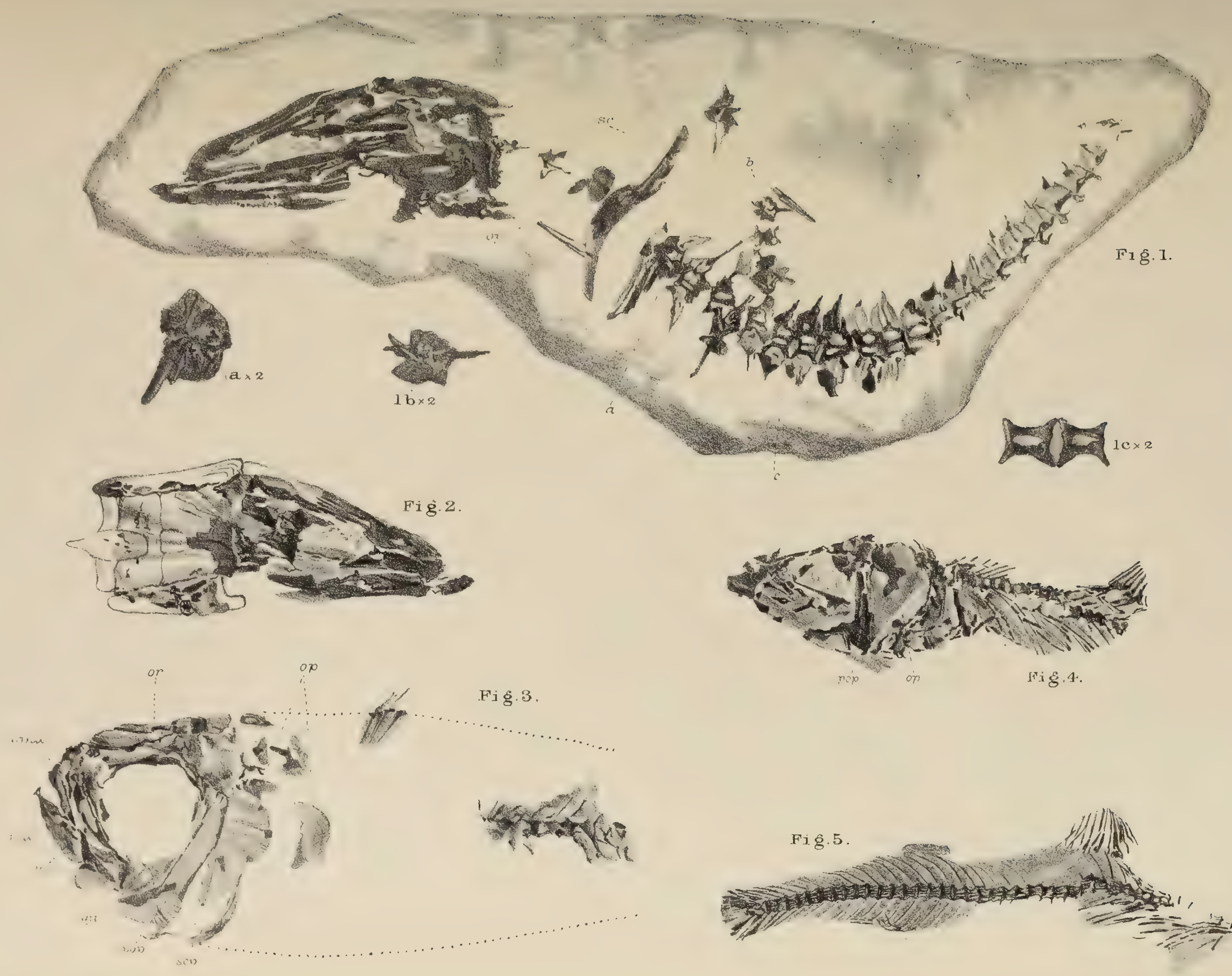
    Limhamn. *Ex coll.*—Geological Museum, University, Lund.

3, 4. *Hoplopteryx minor*, Davis.

    Limhamn. *Ex coll.*—Riksmuseum, Stockholm.

5. *Clupea lundgreni*, Davis.

    Limhamn. *Ex coll.*—Geological Museum, University, Lund.



J. W. Davis del. N. H. Chatwin del.

West, Newman imp.

PLATE XLVI.

FOSSIL FISH OF THE CRETACEOUS FORMATIONS OF SCANDINAVIA.

EXPLANATION OF PLATE XLVI.

Figure.

1, 2. *Bathysoma lutkeni*, Davis.

Limhamn. *Ex coll.*—Mineralogical Museum, University, Copenhagen

3, 4. *Bathysoma lutkeni*, Davis.

Limhamn. *Ex coll.*—Geological Museum, University, Lund.

5. *Bathysoma lutkeni*, Davis. Vertebræ and hæmal spines of a larger example.

6. ,, ,, ,, Anterior one of the same, enlarged.

Limhamn. *Ex coll.*—Geological Museum, University, Lund.

7. *Bathysoma lutkeni*, Davis. Restored.

Or. orbit, *op.* operculum, *p. op.* pre-operculum, *s. op.* sub-operculum, *i. op.* inter-operculum, *mx.* maxilla, *p. mx.* pre-maxilla, *m.* mandible, *sup. oc.* supra-occipital, *cl.* clavicle, *cor.* coracoid, *scap.* scapula, *p. cl.* post-clavicle, *pub.* pubic.

Plate XLVI.

Fig. 1

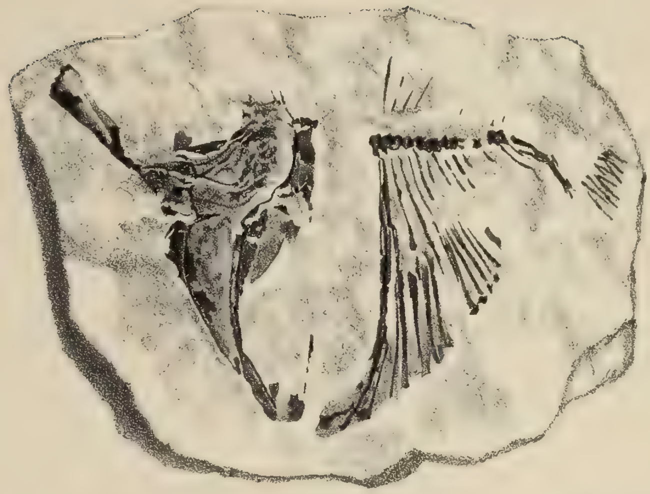


Fig. 2

Fig. 5

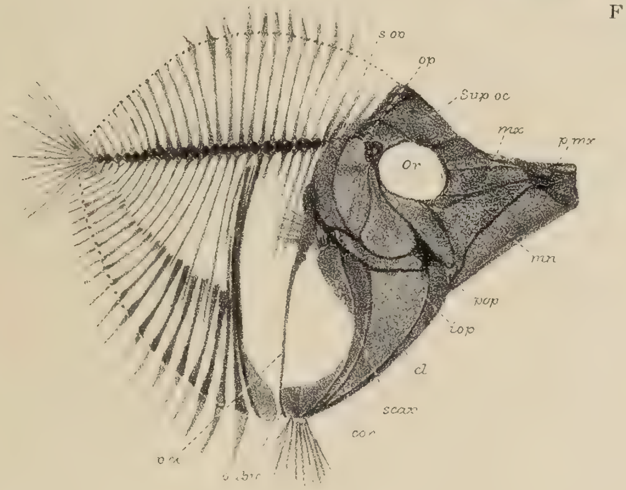


Fig. 7

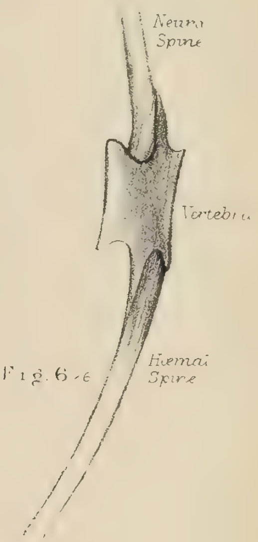


Fig. 6

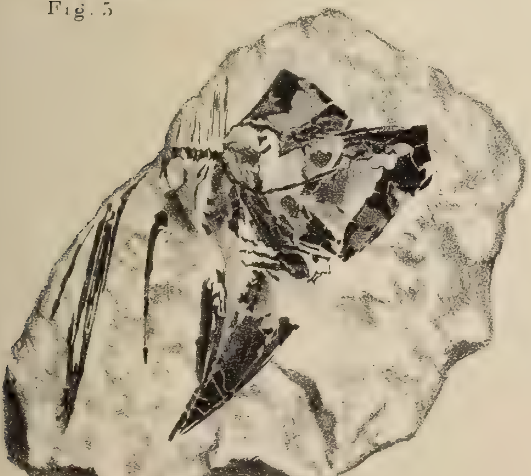


Fig. 8

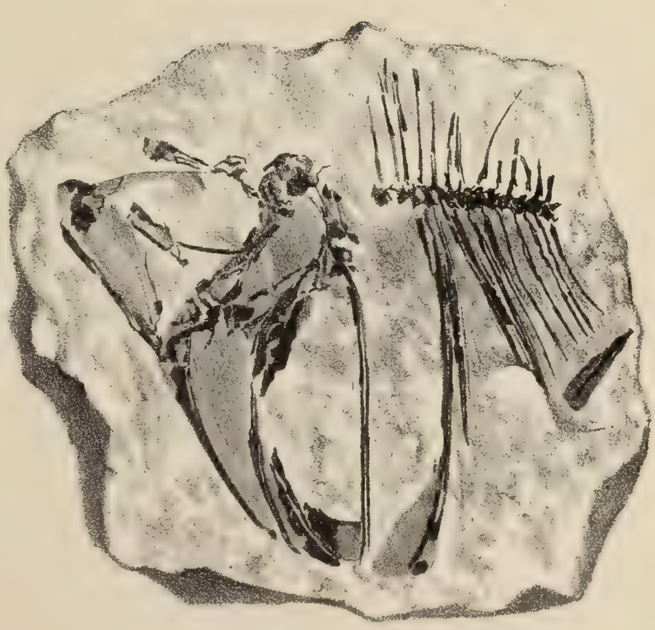


Fig. 4

VII.

SURVEY OF FISHING GROUNDS, WEST COAST OF IRELAND, 1890. I.—ON THE EGGS AND LARVÆ OF TELEOSTEANS. By ERNEST W. L. HOLT, St. Andrew's Marine Laboratory. Plates XLVII. to LII., and Table.

[Read November 19, 1890.]

[COMMUNICATED BY PROFESSOR A. C. HADDON, M.A.]

These Notes comprise a series of Observations on Teleostean ova (and larvæ hatched therefrom, on board) collected off the west coast of Ireland, between Aran Islands on the south and Killybegs Bay on the north, during the cruise of the "Fingal" on the Royal Dublin Society's Survey of Fishing Grounds between the 12th of June and the 11th of July, 1890.

All observations and drawings of the living forms were, of necessity, made on board, and it may be urged, as an excuse for their incompleteness, that a ship, even in fine weather, of which we experienced little, is not the best place for microscopical study, whilst it was only possible to devote to this subject such time as could be spared from the more important duties (in view of the objects of the expedition) of examining the reproductive organs and food of the adult fishes, in addition to faunistic observations and preservation of specimens of special interest. A few further notes on the egg-capsule have been made at this laboratory from specimens brought from Ireland.

The methods used for the capture of pelagic ova were (1) towing at the surface small ring-nets of fine cheese-cloth at the sides of the vessel whilst trawling; (2) sinking larger ring-nets and a large triangular midwater-net, after Professor M'Intosh's pattern, to a fathom or so below the surface, and allowing the ship to drift with them for a short time; (3) sinking ring-nets to various depths whilst at anchor in a tide-way; (4) trawling from the ship's boats with a small naturalist's trawl with muslin net; owing, probably, to some defect in the latter, this method was not very successful. The first method proved by far the most productive, and is convenient, as it can be carried on whilst the ship is trawling. It has one drawback—that one is apt to capture in the net many things not essentially

marine. The second method yields fair results, but necessitates a certain expenditure of time. It also appeared that ova were more abundant at the surface than a short distance below, on the comparatively fine days when this method was adopted. The third method was successful on one occasion in Blacksod Bay on the flood tide, the ova occurring in the surface-net.

Young fish, principally mackerel-midges (Motella) and suckers (Liparis), occurred often in the surface-nets, the latter always amongst drift weed, under which the former also appeared frequently to take shelter. Many other young fish were obtained with the naturalist's trawl with shrimp mesh, but these do not enter into the subject of this Report.

The ova were separated from the rest of the contents of the net by examination in glass tubes at sea, and were sorted, when at anchor, and the different species placed in separate vessels—individuals being further isolated when occasion required. The vessels used were shallow circular jars, or, failing a sufficient number of these, short tubes of $2\frac{1}{4}$ inches by $1\frac{1}{6}$ inch. Accidents were frequent in bad weather, till the vessels were placed in a large zinc tray on a swinging table in the saloon, where they were comparatively safe from upsetting, but open to the attacks of dust. A good supply of water was usually brought in from the open sea, but it was found that frequent changes of water were not beneficial.

In the case of several species only one or two individuals were obtained, which were kept alive as long as possible for observation, and, having finally died, were of little or no service for further investigation.

My best thanks are due to the Director of the expedition, the Rev. W. Spotswood Green, one of H. M. Inspectors of Fisheries, Ireland, for his unvarying kindness in assisting me to obtain specimens; and I have also to thank Mr. T. E. Duerden, of the Royal College of Science, for help in sorting the ova obtained. To Professor Haddon I am also indebted for much help in various ways. Professor M'Intosh, F.R.S., has allowed me to draw up this Report at this laboratory, and has enabled me, by advice and criticism, to add considerably to its value.

A number of pelagic ova were obtained which cannot be definitely referred to any species. I have, accordingly, placed them in a series of Roman numerals—I. to IX.

In the arrangement of the known forms I have followed Günther's classification. The unidentified species have no special arrangement.

My figures are not drawn to a uniform scale. I have, therefore, appended a Table to show the relative sizes of the different ova. The actual dimensions of the young fish are shown in the usual manner in the plates.

SCOMBRIDÆ.

Scomber scomber (Linn). The Mackerel.

About fifty small autumn mackerel, from the neighbourhood of Broadhaven Bay, were examined by Mr. Duerden and myself on the 20th June. We found that many of the males were ripe, whilst the females were, in various stages, approaching ripeness, with the exception of one which was fully ripe.

Day* remarks, on the authority of Dunne, that this species spawns at Mevagissey in May or June; and Cunningham† gives June and the first half of July for the Plymouth district. The period seems to extend to August in Scotch waters.‡ Sars found that spawning usually took place in the first half of July.

TRACHINIDÆ.

Trachinus vipera (Linn.) The Lesser Weever.

(Pl. XLVII., fig. 8; Pl. XLVIII., fig. 15; Pl. XLIX., figs. 31, 32; Pl. L., figs. 37, 38.)

Ova, which have been identified with this species from Brook's description,§ occurred in considerable abundance in the surface-nets in Blacksod Bay on the 15th June and 11th July; in Inver Bay on the 25th, 28th, and 29th June; in Clew Bay on the 30th June; and on several other occasions in these bays.

The diameter is 1·25–1·37 mm.; the yolk is clear, colourless, and homogeneous, and there are (fig. 31) from eleven to nineteen small pale greenish-yellow oil globules (the largest ·06 mm. in diameter) scattered over the upper hemisphere of the yolk. Seen by the naked eye, the globules give a dull yellowish colour to the egg, very similar to that of the common sole's egg. The egg-capsule is thin, but tough and resistant.

In flattened preparations, under a high power, an optical section shows that it is divisible into an outer homogeneous layer (fig. 8, *v. m.*) and an inner layer (*st.*) showing four or five stratifications. The two layers are of about equal thickness (fig. 8). Treated with picro-carmine, the outer layer takes only the yellowish stain, whilst the stratified part is very faintly affected by the carmine. The double nature of the egg-capsule, in this species, was observed by Brook (*op. cit.*, p. 275), who considers the outer layer as the vitelline membrane, according to the definition

* British Fishes. Vol. i., p. 89.

† Reproduction and development of Teleostean fishes occurring in the neighbourhood of Plymouth. Journal of the Marine Biological Association. N.S. No. 1, March, 1889, p. 25.

‡ Brook. Spawning period of British food-fishes. Report Scot. Fish. Board, 1885.

§ On the development of *Trachinus vipera*. L. S. Journal Zoology. Vol. xviii. p. 274.

of Balfour. It is doubtful whether it really represents anything more than an unusually thick lamina of the zona.* The inner layer (*st.*), in which Brook noticed no stratifications, is regarded by him as the zona-radiata; and he remarks that the two layers are occasionally separated by a space. I noticed an extreme opacity in the capsule of an apparently healthy egg, which may, perhaps, be accounted for by such a separation of the layers.

Brook gives from twenty to thirty as the number of the oil globules, whereas, I found only from eleven to nineteen in a considerable number which I counted, whilst Raffaele† found only from four to ten in ova of 1·166 mm. which he refers to this species, remarking that the slight discrepancy is probably due to local variation. Brook makes no mention of any colouration of the globules, which are distinctly yellowish (as in Raffaele's) or yellowish-green (fig. 31) in my specimens, both early and advanced. I noticed one exception in which, at a very early stage, the globules were colourless, but acquired an unusually pale yellowish tint as development proceeded. As regards development, I have little to add to Brook's excellent account.

Pigment of a pale yellow colour (black by transmitted light) appears in minute round chromatophores in the embryo before the outgrowth of a free caudal region, and spreads outwards from the sides over the yolk sac, the whole of which is eventually studded with it (as in fig. 32). When the embryo possesses a free caudal region equal to the rest of its length, the yellow chromatophores have become larger and stellate, with a brilliant orange hue (brown by transmitted light); they extend dorsally and ventrally along the free caudal region almost to its posterior extremity, and along the gut on either side. Small black chromatophores (fig. 32) have also appeared, following the course of the yellow pigment in the postanal region, and distributed sparingly and somewhat irregularly over the anterior part of the body. Stellate black chromatophores, much less abundant than the yellow, occur on the yolk sac. Thus, at a comparatively late stage of development *in ovo*, the yellow pigment is altogether in excess of the black, a condition which is reversed in the older stages. The black chromatophores of the trunk become stellate and increase greatly in size; they appear on the brain, about the eye and the large otocysts, on the base of the pectorals, and on the pelvic fins, whilst the yellow pigmentation of the trunk appears to diminish.

In the recently extruded larva (fig. 37), still mouthless and with comparatively large yolk (*y*), the black pigment of the trunk forms a conspicuous line, dorsally and ventrally, from the pelvic fins to the commencement of the posterior fourth of

* *Cf.* M'Intosh and Prince, "On the Development and Life-Histories of the Teleostean Food and other Fishes," Trans. R. S. E., vol. xxxv., pt. iii. (No. 19), p. 671.

† "Le nova gallegianti e le larve dei Teleostei nel golfo di Napoli.," Mittheil. a. d. Zool. Stat. zu Neapel., Bd. viii. 1, p. 30.

the notochordal region, thus differing from the condition shown in Brook's newly-hatched larva (*op cit.*, pl. 6, fig. 27). Thereafter the black pigment of this region tends to become concentrated into two bars—one midway along the post-anal region, and the other above the anus, sending dendritic lines on to the dorsal fin, which apparently mark the site of the future first permanent dorsal fin (fig. 38, d. I.). This is the condition when the postlarval condition is reached (fig. 38) when all yellow pigment has disappeared, except three patches along the margin of the embryonic-dorsal fin. The eyes are black, and the roof of the abdomen and the rectum are profusely pigmented. There is, thus, at this stage, no practical difference from the condition shown in Brook's figure of an embryo of three days (*op. cit.*, pl. 6, fig. 29).

The most interesting condition in this form is the development of the paired fins. At a comparatively early stage (fig. 15) what appears to be a fold of epiblast is pushed out from the lateral region of the embryo, occupying about the middle-third of the pre-anal length, and never, as far as can be seen, extending back to the region of the embryonic-ventral fin. The anterior and posterior portions of this fold develop rapidly, forming a couple of slight prominences connected by a narrow ridge (*c. r.*). The prominences represent the pectoral (*p. f.*) and pelvic (*pl. f.*) fins, which thus, at their earliest stage, are connected by a continuous epiblastic ridge, which may even be regarded, as Balfour suggests in Elasmobranchs,* as a continuous lateral fin.

Though at first equal,† the pectoral soon outstrips the pelvic fin in development, and the connecting ridge disappears or becomes very inconspicuous. At hatching (fig. 37) the pelvic (*pl. f.*) still retains its original position behind the pectoral (*p. f.*), the bases of the two being in the same straight line. As the yolk is absorbed, the pectoral undergoes the usual rotation, and is carried downwards and forwards to the clavicular region (fig. 38, *p. f.*), whilst the pelvic (*pl. f.*), now growing more rapidly, is similarly rotated, and travels downwards and forwards to a ventral position a little behind the pectoral; the assumption of the jugular position is a feature of later development.

From Brook's account ("L. S. Journal," vol. xviii., p. 298) it appears that the pelvic fins appear very early in *Motella mustela*, though this was not noticed by M'Intosh and Prince (*op. cit.*) in the same species, nor by Raffaele (*op. cit.*) in *Motella tricirrata*.

Pelvic fins do not appear till much later in all other Teleosteans with pelagic ova, of which the development has been studied.

* "Comparative Embryology," vol. ii., p. 611.

† Brook speaks of the pelvic fins as appearing later than the pectoral, but both fins seemed to me to be developed at the same time.

The newly-hatched larva (fig. 37) measures 3·27 mm. in total length, the pre-anal length being 1·49 mm. The marginal fins are of moderate size; the dorsal commences on the mid-brain; the caudal is spatulate, with embryonic fin rays, and there is a very minute pre-anal fin (*pa. f.*). The notochord is multicolumnar. The oil-globules (*o. g.*) lie principally along the ventral surface of the yolk. There is no mouth, and the anus (*a.*) is imperforate. A small urocyst (*u.*) is present.

When the postlarval stage is reached (fig. 38) (about three days after hatching) the total length is 3·51 mm., the increase being in the post-anal region. The marginal fins are broader; the dorsal extends to the snout. The mouth is open, with well-developed jaw and branchial apparatus, and the anus is perforate.

Raffaele notes that the ova of this species are shed in spring, and take about eight days to hatch, the last three or four days being spent at the bottom. Brook ("Spawning Period of British Food Fishes," *loc. cit.*) gives April, May, and early June as the spawning period on the Yorkshire coast, and June and July in his Aquarium. Day gives spring. A single egg has been obtained this year at St. Andrew's in the latter part of July.

Cottidæ.

Trigla gurnardus. *Grey Gurnard.*

The well-known ova of this species* occurred frequently in the tow-nets, and many ripe as well as spent females occurred in the trawl. Possibly some of the ova attributed to *T. gurnardus* may have belonged to *T. cuculus*, as Cunningham (*op. cit.*) has shown that the ova of these two species are identical in dimensions, whilst his descriptions of the later development of the latter species afford no distinctive character. The length of the larva is the same in both, and the great size of the rudiment of the pectoral fin, which he describes as the most peculiar feature of the larva, is equally well marked in *T. gurnardus*.

Trigla hirundo, the sapphirine gurnard, is another species which appears to spawn about June and July, and probably later, as we obtained several males with enormously developed testes, which gave them the appearance of pregnant females. No females were obtained. Couch gives from January to June as the spawning period of this species.

* *Cf.* Cunningham, *op. cit.*, p. 11; and M'Intosh and Prince, *op. cit.*, p. 806.

Gobiidæ.

Gobius niger (Linn.)(?) The Black Goby.

(Pl. xlvii., fig. 12.)

A post-larval goby, 11 mm. long, occurred in the bottom net in Blacksod Bay on the 14th June.

From the nature of the pigment, I am inclined to refer it to this species. The young of *G. minutus* and *G. ruthensparri* have been long known at St. Andrews, though they cannot as yet be with certainty distinguished in their earlier stages. Their pigmentation is, however, uniformly pale, differing markedly from what is seen in this specimen. The jaw apparatus is fully developed, but no teeth are visible. The head is large, with slightly upturned snout; the lower projects beyond the upper jaw. A large translucent opercular flap (*op.*) is present; the gill arches are serrated. The large otocyst has a dorsal prominence, and shows considerable resemblance to that of the larval Gobius, figured by me in Ann. and Mag. Nat. Hist.† The clavicle (*cl.*) is conspicuous: its inferior half is forwardly directed, and is overlapped by the opercular flap (*op.*). The pectorals are very large and fan-shaped, and the fin-rays are conspicuous, as in the early larva.

The abdomen is contracted, and tapers off from the middle of its length to the anus (*a.*), which is somewhat posterior to median. The air-bladder (*a. b.*) is very conspicuous as a large ovoidal sac, lying in the sub-notochordal region at the top of the abdomen. The marginal fins still persist, but the fin-rays of the permanent second dorsal (*d. l.*) and ventral (*p. v. f.*) fins are seen. There is no sign as yet of the first dorsal; but this fin, judging from the young of other species, is very late in making its appearance in fishes of this genus. The notochord is still visible, but the abundance of pigment renders its structure obscure. The extreme posterior end of the caudal region is slightly turned up, and there is a deeply pigmented pyriform hypural lobe (*hp.*) from which, as from the upturned notochordal region, embryonic fin-rays extend into the spatulate caudal fin. There is a considerable pre-anal fin (*p. a. f.*). The eyes are black, with dark-greenish lights. The surface of the head and body is covered with a dull olive-green pigmentation, which is only absent from the pectoral and marginal fins, opercular flap, and the tips of the jaws. This green colour is somewhat darker on the top of the head and abdomen than elsewhere, and small black chromatophores are distributed pretty thickly over it, except in the upturned caudal region. In addition to this, four bands of reddish-brown stellate chromatophores cross the body at various points. The first descends obliquely from the dorsum, passing just behind the air-bladder to the ventral edge. The second crosses vertically at

† "On the Ova of Gobius," s. 6, vol. vi., July, 1890, pl. vi., p. 39.

the level of the anus, and is widest dorsally and ventrally. The third band is not very conspicuous; it lies at the commencement of the 2nd third of the post-anal region of the trunk.

The fourth and last band is the most conspicuous and broadest, embracing the hypural thickening, and the trunk for some distance in front of this.

From the abundance of the pigment, the body has little translucence. The reddish-brown, conspicuous by transmitted light, is not distinguishable by reflected light from the surrounding black pigment.

The general effect to the naked eye is a dark olive-green, crossed by black bands at the regions described.

Compared with the figure of the larval goby, the anus in this specimen is seen to be much further back, occupying indeed a position posterior to that seen in the adult. Such a condition occurs also in late post-larval and young specimens of *Gobius ruthensparri* and *G. minutus*.

The ova of *Gobius niger* are figured in the note previously referred to.*

Callionymus lyra (Linn.). The Dragonet, &c.

(Pl. LI., figs. 40–42.)

A few ova of this species were taken in the surface net off Cleggan Head on the 12th June, in Inver Bay on the 20th June, and in Blacksod Bay on the 10th July.

The eggs are well known, but the larva has hitherto escaped attention. I was successful in hatching two eggs on this occasion.

The newly-hatched larva (figs. 40 and 41) has a total length of 2·08 mm., of which the head and yolk (*y.*) occupy ·895 mm. The snout is as yet blunt, and the head has the rounded contour usual in early larvæ from pelagic ova. The eyes are comparatively large at this stage, with a conspicuous choroidal fissure. The otocysts (*ot.*) are small and oval, and as yet remote from the eyes. The cerebellar fold is rather large, but the pineal sac is not as yet visible. The heart (*h.*) is lodged in a depression of the yolk (*y.*), which is still very large, ·835 mm. by ·595 mm. The yolk sac (*y. s.*) is rather thick, and exhibits certain irregular nodosities in optical section (*cf.* fig. 40). Faint striæ are visible on the surface of the yolk, which has a slight median lateral constriction. The body has somewhat of an S flexure (fig. 41), being incurved over the yolk, and upturned midway between the latter and the posterior extremity. The gut is small, but is tubular for part of

* In this note, while referring to Hoffmann's work on the subject, I overlooked a figure (Taf. III., fig. 9) described as the egg of *G. minutus*. I cannot regard Hoffmann's identification as correct, since he shows the attachment process as a ring of simple filaments, very different from the reticulate condition of that structure which I have observed in the ovarian eggs of *G. minutus*.

its length. Its thickened region fails to reach the hinder end of the yolk, and terminates in a conical process, from which the narrow cord-like rectum (*r.*) passes down along the posterior of the yolk sac to the marginal imperforate anus (*a.*).

The marginal fins (fig. 41) are of moderate size, and about equal in height with the free caudal region of the trunk. The dorsal commences behind the otocysts (*ot.*), the caudal is short and rounded, and the ventral sends forward a narrow strip along the postero-ventral border of the yolk sac (*y. s.*).

The notochord (*no.*) is unicolumnar throughout; the cells do not show the same ampullation as in the herring, &c. The pectorals have not appeared. The pigment is a bright orange, dark by transmitted light. It occurs in a conspicuous patch on the snout. There is a well-marked bar (*p. b.*) extending into the dorsal fin, across the middle of the free caudal region of the trunk, an arrangement common to many larval fishes. In front of this, two lines of round chromatophores, dorsal and ventral, run forward along the sides to the cephalic region, the dorsal line extending on the top of the midbrain. Similar chromatophores are scattered over the posterior moiety of the yolk sac, and a few occur on the edge of the ventral fin near its commencement.

Two large pigment patches occur on the edge of the anterior half of the dorsal fin, and there are a number of small chromatophores along the bases of the dorsal and ventral fins about the posterior extremity of the body.*

The newly-hatched larva, whilst presenting resemblances to that of *C. festivus* (see Raffaele, *op. cit.*, p. 33) in the character of the pigment and the large size of the yolk, differs from that form in the possession of a well-developed heart at the time of extrusion.

Raffaele says nothing definite as to the dimensions of the larva ("piccola"), nor does he allude to the structure of the notochord in the Mediterranean species. From his figure of the newly-hatched larva, it is evident that the rectum is even at that stage separated from the yolk.

I cannot say anything as to the time the egg of *C. lyra* takes to develop. In the specimens described above the embryo was considerably advanced when taken on the evening of the 20th June, and hatched on the following day. The faint striæ noticed on the yolk surface in the larva may have some relationship to the vesicular layer of the yolk of *C. festivus*, though it is remarkable that, if any trace of such a structure exists in *C. lyra*, neither M'Intosh† and Prince or Cunningham should have detected it in the ova. I certainly saw nothing of the sort in any of the ova that came under my notice.

* Whilst under observation minute tubercles made their appearance all over the integument of this specimen (as shown in figure 41). Death ensued shortly afterwards.

† The ovum of this species was first described by Professor M'Intosh in the Ann. and Mag. Nat. Hist. Dec. 1885.

Another egg of this species, which on the 30th June contained an advanced and pigmented larva, was found twenty-four hours later to have hatched. The larva (fig. 42) is probably now at least twelve hours old, and shows a considerable advance on the newly-hatched condition. The total length is 2·20 mm., having increased by ·12 mm. The yolk is much reduced, and has now an elongated ovoidal shape, narrowest in front. The fore brain has undergone a certain upward rotation and the pineal (*pn.*) is visible as a distinct prominence in profile. No mouth is as yet present, but the development of a pre-nasal rostrum has increased the acuteness of the frontal angle, imparting to the head something of the shovel-like contour familiar in the adult. The hind brain is shortened, bringing the otocysts (*ot.*) nearer to the eye. There is as yet no appearance of the enormous development of the brain met with in older stages,* and the eye is still comparatively large. The pectorals (*p.f.*) have appeared as small semicircular flaps in rear of the otocysts. Beneath them the gut shows a dilatation. The posterior region of the gut now extends some way behind the yolk under the notochord, the cord-like rectum (*r.*) descending to the marginal imperforate anus (*a.*) at a short distance behind the yolk (*y.*), a condition due to the shortening up, by absorption, of the latter. The post-anal region measures 1·18 mm., the anus being slightly anterior to median.

The marginal fins have undergone considerable expansion, especially the dorsal, which now commences at the snout, passing up over the fore- and mid-brain as a narrow fold, and thence increasing till it reaches its greatest height above the posterior extremity of the yolk. The embryonic caudal fin is not affected by this expansion, but embryonic fin rays have appeared in it (fig. 42).

The arrangement of the pigment has undergone certain changes. The chromatophores over the posterior two-thirds of the yolk sac have become stellate. Pigment has appeared round the inner edge of the iris. The body pigment is now restricted to the neighbourhood of the otocysts, the post-anal band (*p.b.*), which is more conspicuous, and the caudal extremity, where the chromatophores are now aggregated into a dorsal and ventral patch. The two lateral lines of chromatophores in the anterior region have disappeared, or have in part migrated to the posterior extremity of the tubular part of the gut, and the narrow rectal region. One chromatophore occurs on the pectoral fin.

The two marginal patches of the dorsal fin have increased in size, but have migrated backwards, and now occupy the extremities of the central third of the expanded portion of the fin (*i.e.* the part between the mid-brain and caudal fin). A large marginal patch has appeared on the ventral fin below the post-anal bar, and small chromatophores occur along the edge of the fin from this point to the

* *Cf.* M'Intosh and Prince, *op. cit.*, p. 864.

yolk. None of the darker pigment characteristic of the older forms has as yet appeared.

No striations of the yolk are visible in this specimen. Compared with Raffaele's figure of a larval *C. festivus* on the second day after hatching, it is seen that the marginal pigment patches of the dorsal and ventral fins are characteristic of both forms. In the Mediterranean species the development of the brain, and in our own that of the snout, seems the more precocious, the exaggeration of both structures being characteristic of the older forms of *C. lyra*.

It may be permissible here to advert shortly to the question of the affinities of this form. Raffaele remarks that in development and early conditions it has nothing in common with the Gobies, amongst which it is classed. The hexagonal marking of the zona (vitelline membrane), so conspicuous in *C. lyra* (but absent in *C. festivus*), was found by Raffaele also in the fertilized egg of *Uranoscopus scaber*, and in the ovarian egg of *Saurus lacerta* (*op. cit.*). Putting aside Saurus, Cunningham (*op. cit.*, p. 37) regards the occurrence of this common feature in Callionymus and Uranoscopus as suggesting "some interesting possibilities with regard to the true systematic affinities of these two genera," the latter of which is classed with the Trachinidæ. He alludes to certain peculiarities of adult structure common to the two forms, and points out that whereas the Trachinidæ are mostly laterally compressed, Uranoscopus is depressed from above downwards, and has the two eyes directed upwards and placed on the flat upper surface of the head. This, it may be remarked, is equally true of *Gobius minutus*.

Cunningham concludes that it is probable that "Callionymus and Uranoscopus are closely allied, and that either the Callionymina ought to be included among the Trachinidæ instead of among the Gobiidæ, or that the Callionymina and Uranoscopina form a single family distinct both from the Gobies and the Weevers." The fact that the eggs of the typical gobies are adhesive whilst those of Callionymus are pelagic appears to me of no great weight, as both pelagic and demersal eggs occur in the Labridæ, and even in the single genus Clupea; and such goby-eggs as are known to us, so far from being typical, are as aberrant in their own way as those of Callionymus. That the presence of oil-globules in the ova of Trachinus and their absence in those of Uranoscopus can be regarded as seriously lessening the chance of affinity between these two forms appears improbable, as oil-globules are present or absent in the ova of different species of the same family, such as the Labridæ and Gadidæ, and even in the same genus (*e. g.* Clupea). The occurrence of the hexagonal marking in Saurus would seem to indicate that no great importance can be attached to this structure. Saurus is one of the Scopelidæ, a Physostomous family having certainly no close relationships to either of the other forms.

As to the relationships of Callionymus to the gobies it may be pointed out that the unicolumnar condition of the notochord, by no means a common feature,

occurs in both Gobius and Callionymus, though too much stress should not be laid on a feature which appears in widely separated groups, and is variable within the limits of a single genus.*

In Callionymus and Gobius, the notochord cells (vacuoles) are smaller and less inflated than those of the herring, which Kupffer (Entwickelung des Herings im Ei. Jahresb. Comm. deutschen Meere. 1874–76: Berlin, 1878) has shown to arise from more numerous and smaller roundish polygonal cells. Of the origin of those in the dragonet and goby we have at present no knowledge.

CEPOLIDÆ.

Cepola rubescens (Linn.). The Red Riband Fish.

(Pl. XLVIII., fig. 22.)

A female of this species, $11\frac{1}{2}$ inches long, occurred in the stomach of a large grey skate in Inver Bay, on the 25th of June. It was somewhat macerated, and the ripe ovaries, with other viscera, were exposed. A number of ripe ova were scattered about in the skate's stomach. The ovum (fig. 22) is translucent, with a thin minutely-pitted zona. The diameter is ·72 mm. The yolk (*y.*) is homogeneous, translucent, and colourless, except at the periphery, which exhibits a brownish opacity in optical section. It is somewhat collapsed, a condition which, with the brownish tinge, is doubtless due to the action of the gastric juices. The zona shows no sign of collapse, and appears perfectly spherical. There is a single large oil-globule, 1·35 mm. in diameter, with a somewhat smoky margin, like that of *Trigla gurnardus.*

From its small size, thinness of zona, and character of yolk, I am inclined to regard this as a pelagic egg. My specimens were, of course, of no service in demonstrating the buoyancy (or otherwise) of the living egg.

This species is abundant in the Mediterranean, but the ova, if pelagic, have escaped Raffaele's attention.

* A unicolumnar notochord occurs in *Pleuronectes americanus.* See Agassiz and Whitman, "The Pelagic Stages of Young Fishes"—Memoirs of the Museum of Comparative Zoology, vol. xiv., No. 1, pt. i., pl. XVI., fig. 5. It is not known to occur elsewhere in the Pleuronectidæ. In the genus Clupea it is present in *C. harengus, C. sprattus,* and *C. pilchardus;* but the notochord of *C. sapidissima* is multicolumnar. See Ryder, "The Development of Osseous Fishes"—U. S. Commission of Fish and Fisheries, pt. xiii., Report of Commissioner for 1885, p. 523.

Gobiesocidæ.

Lepadogaster bimaculatus (Donov.). The Doubly-spotted Sucker.

(Pl. xlvii., figs. 1–7.)

On the 12th June a whelk-shell was obtained in the trawl in Clifden Bay, and proved to contain a specimen of *Lepadogaster bimaculatus.* On breaking the mouth of the shell a number of ova were revealed, attached to the inside of the last whorl near its commencement.

The shape of the ova (figs. 1–3) is remarkable. They are not globular, as described by Hyndman,* but ovoidal and abruptly truncated inferiorly (fig. 1), having something of the shape of an ordinary dishcover. The length is 1·37 mm., the breadth 1·08, and the height ·68 mm., but these dimensions, as also the contour, are subject to slight variations. There is a single, large, colourless oil-globule (*o. g.*) of 24 mm. M'Intosh and Prince (*op. cit.*, p. 672) noted that the zona shows very evident punctures.

The flattened under-surface of the egg (fig. 4) adheres to the shell by means of a remarkable attachment apparatus. The micropyle is central, and is closed in the somewhat advanced stages studied. Its site is visible from below as a minute clear, oval area (*mi.*), from the edges of which numerous interlacing fibrils radiate outwards, forming by the cohesion of their distal ends a structure resembling a shallow circular basket with a thickened rim (*r. p.*), from which are given off very numerous fine filaments (*fil.*) of considerable length. It is evident that these filaments have an adhesive function in the freshly-extended ovum. In favourable preparations it is seen that this plate-like structure is continuous with the rest of the zona only in its centre, *i. e.* around the micropyle (*mi.*). In addition to this central apparatus the whole of the flattened surface of the zona is studded by numerous short, stout, rod-like bodies (*rd.*), having rounded bases springing from the zona, whilst their distal extremities, which are directed towards the periphery, bifurcate, and thereafter taper very rapidly into long and extremely fine adhesive filaments (*fil.*, fig. 4) similar to those of the central structure. These can be seen, in an isolated egg viewed from above (fig. 3), projecting as a fringe (*fil.*) beyond the edges of the inferior surface. The zona is of moderate thickness, and there appears to be no layer external to it. Treated with picro-carmine it takes on the carmine stain faintly, whilst the attachment apparatus is entirely unaffected by it, with the exception of the thickened rim (fig. 4, *r. p.*) of the central structure. This

* This observer gives about $\frac{1}{16}$ inch as the diameter. Day, "British Fishes," vol. i., p. 193.

is somewhat remarkable, as the attachment process in the egg of Gobius* takes the carmine stain very deeply and readily.

The yolk (*y.*) is colourless and translucent, and very finely granular. The oil-globule (*o. g.*) appears to occupy a variable position, as in some other demersal ova; the embryos in different ova at the same time present such differences in development as to induce the belief that the parent deposits them in batches from time to time. Judging from Mr. W. Anderson Smith's account (Notes on the Sucker Fishes, Liparis and Lepadogaster: Proc. Roy. Phys. Soc., Edin., vol. ix., 1886, pt. i., p. 145) the eggs of *L. decandolii* are all deposited at the same time, as is the case with most demersal ova. In some of the ova before us the embryo at the time of capture had a long, free, caudal growth, others had no free caudal growth, and only four protovertebræ (fig. 3), whilst intermediate stages occur. In the least advanced stages a large Kupffer's vesicle (*k. v.*) was present. The embryo occupies a horizontal position in the egg, the yolk (*y.*) being laterally compressed. Mr. Anderson Smith notices great irregularity in position in the embryo in the eggs of Lepadogaster, but in my specimens the horizontal position appeared constant. I did not experience the difficulty met with by that observer in isolating the ova of this species; on the contrary these appeared much easier to isolate than such demersal ova as those of Centronotus, which adhere to each other, and possess no attachment processes.

The larva, on emerging (figs. 6 and 7), has a total length of 2·97 mm.,† of which the pre-anal region occupies 2·08 mm. The yolk (*y.* and fig. 5) is small, transversely elongated, and somewhat bilobed. Anderson Smith noticed that it is smaller than in *L. decandolii*. The head is large, and the parts of the brain are easily made out, the medulla (*m. o.*) rising to a conspicuous hump behind the cerebellum. The eye is large, with a comparatively large pupil. The otocysts are large and near the eyes. The top of the head and back are very much flattened, a condition well shown in a dorsal view of the larva (fig. 7). The pectorals (*p.f.*) are stout and fan-shaped. The gut, which extends far back, is very large; the anus (*a.*) is perforate. The mouth (*m.*) is subterminal, and the turning up of the mandibular symphysis below, and short of, the anterior extremity of the upper jaw imparts a characteristic appearance to the head. The marginal fins are narrow; the embryonic caudal somewhat lanceolate, and a very narrow pre-anal fin (*p. a.f.*) extends from the yolk to the anus. The only pigment I could detect is black, and takes the form of small round chromatophores. These occur on the lower jaw, along the ventral region of the yolk sac on the pectoral fin, dorsally and ventrally on the gut, and in four ill-defined rows along the sides of the body, except at the

* *Cf.* "On the Ova of Gobius"—Ann. and Mag. Nat. Hist., July, 1890, p. 37.

† Some as long as 3·15 mm., and advanced in pigmentation.

extreme posterior end. Of these four rows the most dorsal marks the boundary of the flattened dorsal region, and extends forward on to the mid-brain (*m. b.*); whilst posteriorly several chromatophores occur between the two rows. Post-anally the ventral rows unite to form a single line along the ventral edge of this region.

The pigmentation of the eyes is variable: in some larvæ there are only a few chromatophores on the iris, which is perfectly black in others.

There is considerable resemblance to Mr. Anderson Smith's figure of the larva of *L. decandolii.* The gut appears to extend further back in our species. Mr. Anderson Smith also figures ova of *L. decandolii*, from which it appears that they are nearly circular, and contain a single large oil-globule. He mentions that they have a pinkish tinge, which distinguishes them from those of *L. bimaculatus*, but he gives no dimensions of the eggs or larvæ of either species, and does not allude specially to the shape nor to the method of attachment of the eggs. He points out that both species spawn in June and July, and that the ova are hatched in twenty-eight days. Those of *L. bimaculatus*, according to the same authority, are almost always arranged in regular layers (a condition which I did not notice in my specimens), within the empty shells of *Pecten opercularis.* Day, on the authority of Mr. Hyndman, records them from the shells of *Venus virginea* and *Pectunculus pilosus.*

Labridæ.

Labrus maculatus (Bl.).* The Ballan Wrasse. The Gunner (Mayo Coast.)

Raffaele (*op. cit.*, p. 35), observes that the ova of Labrus (*L. merula*, &c.), and Crenilabrus (*C. griseus*, *C. mediterranus*, and *C. pavo*) are demersal, the former being adherent, and the latter non-adherent.

Day (*op. cit.*, vol. i., p. 253) gives the breeding season of *L. maculatus* on the Galway coast as about June, and quotes Moreau to the effect that this species and *L. mixtus* form nests for the reception of their spawn.

Day's observations on the breeding season are to some extent confirmed by our own experience. We obtained specimens only on one occasion, the 8th July, at Inishkeagh.

They were all spent, males and females alike; but several of the females appeared to have spawned recently, judging from the condition of the few ova which, as usual, were retained in the ovaries. They are spherical, and the diameter is from 1·01 to 1·07 mm., in some instances reaching 1·13 mm.

In most the egg contents are reduced to an opaque ochreish granular mass, occupying the centre of the egg, whilst in a few of the larger ones the yolk has a diameter of 1·01 mm., and is colourless and translucent, except for an irregular

* *See* note on p. 473.

central opacity. In some the yolk fills the entire available space, as in fresh ripe ova before fertilization. The zona is somewhat thick, and minutely punctured. No external membrane or attachment process can be made out, and it is to be supposed that the ova, if adherent, as in the Mediterranean species of this genus, are so in virtue of a viscous oviducal secretion, as in Cottus, Cyclopterus, &c. The yolk is extremely resistant in spirit preparations, and appears to possess a thin outer membrane (periblast), having a dotted surface presumably corresponding to the punctures of the zona.

Crenilabrus melops (Linn.). The Cork-wing Wrasse, &c.

On the 12th June I obtained some apparently ripe ova from females of this species in Clifden Bay. They were colourless and translucent, and the yolk appeared perfectly clear. No oil-globule was present. Unfortunately my measurements of these ova have been mislaid.

On the 7th July I again obtained some females in Blacksod Bay. In one of them the ova appeared about three-quarters ripe; they were opaque and ochreish yellow, ovoidal in shape, having a long and short diameter of ·60 mm. and ·48 mm. respectively. The other females were either spent or immature.

It is noticeable that this species comes to maturity at a very small size. Of a number that I examined, both male and female, every specimen exceeding 4 inches in size had well-developed reproductive organs, either approaching maturity or recently spent. A male of 10 inches, the largest obtained, had partly spent testes.

From the spent females I obtained a few eggs that had been retained in the ovaries, as happens frequently in Teleosteans.

They are spherical, with a diameter of ·78 mm. The yolk is colourless, but has a milky-white opacity, probably due to incipient decomposition.

The zona is, as usual, covered with minute punctures. There is no attachment process, and optical sections do not show the division of the egg-capsule into two layers, such as Hoffmann (Zur Ontogenie der Knockenfische, p. 18, Verhand. Konink. Akad. v. Wetenschappen, 1881) found in *C. pavo*. According to this observer, the egg of the latter has a diameter of ·75–78 mm., while the newly-hatched larva is 3·6 mm. long. List (Zur Entwickelungsgeschichte der Knockenfische, I. Labriden; Zeit. f. wiss. Zool., vol. xlv., 1887, pp. 595–645) examined the ova of five species of this genus from the Adriatic, and gives an excellent account, with figures, of the development *in ovo* of *C. tinca* and *C. pavo*. He gives ·9 mm. as the diameter of the egg of the former, remarking that that of the latter is somewhat larger, thus disagreeing with Hoffmann's measurements. The yolk appears to be yellowish in both species. At hatching the larva of *C. tinca* is

2·5 mm. long, that of *C. pavo* being longer and more advanced. In both the mouth is unformed, the notochord is multicolumnar, and the anus posterior to median, with a considerable embryonic pre-anal fin. In addition to yellow pigment, there are very large stellate chromatophores of bright blue, a colour not usually met with in body pigment of teleostean larvæ. There is no pigment on the marginal fins.

List further observes that the zona is divisible into two layers—the outer consisting of regular hexagonal prisms, whilst the inner is faintly stratified. M'Intosh and Prince (*op. cit.*, p. 673) show that the zona of *Liparis montagui* exhibits similar hexagonal markings, but do not record an inner layer. The condition recalls that of Callionymus and other forms.

Gadidæ.

Merluccius vulgaris (Cuv.). The Hake.

A female with nearly ripe ovaries occurred in the trawl in Inver Bay, on the 25th June.

A few translucent and apparently ripe ova were obtained; they were not quite spherical, having a long diameter of 1·35 mm. and a short diameter of 1·08 mm., with a single large oil-globule of ·30 mm.

Raffaele (*op. cit.*, p. 37) gives 0·94–1·03 mm. with oil-globule ·27 mm. as the dimensions of the ova of this species, which he describes as spherical.

The spheroidal condition of my ova was perhaps abnormal, as they were not perfectly fresh when measured, but they were certainly larger than in the Mediterranean form.

According to Raffaele this species spawns at the end of January in the Mediterranean. Brook gives March to May, and June to September as the spawning period on the west and east coasts of Scotland, respectively, quoting Couch to the effect that the period on the Cornish coast is August.

The large size of the oil-globule renders this a very conspicuous egg, which should be easily recognized if obtained in the tow-nets.

Macruridæ.

Macrurus, species?

Amongst the contents of the trawl from 450 fathoms off Achill Island, on the 10th July, were two large females, of a species not yet identified,* with enlarged ovaries.

* Since identified as *M. rupestris*.

The eggs, which appear about three-quarters ripe, or less, are spherical, opaque, and whitish. The diameter in the largest is from 1·25–1·31 mm. There is as yet no appearance of a single oil-globule, though oleaginous matter is, as usual, abundant in the egg contents. The zona, surrounded by the granulosa, is thick and multi-laminate, with very conspicuous radial pores, terminating in minute surface punctures. There is no trace of the mosaic of concave hexagonal facets described and figured by Raffaele (*op. cit.*, p. 65) in his species No. 4, attributed to this family, nor does an optical section show the tubercles found by Costa on the ovarian egg of *M. cœlorhynchus.* My specimens, however, had still a considerable period of intra-ovarian life before them.

PLEURONECTIDÆ.

Rhombus lævis (Rondel). The Brill or Britt.

(Pl. XLVIII., figs. 13 and 14.)

A female was obtained in Blacksod Bay on the 16th June, and proved to contain ripe ova: I could not fertilize them, as no ripe male occurred on the same occasion.

The ripe unfertilized egg (fig. 13) floats buoyantly, and has a diameter varying from 1·25 mm. to 1·37 mm., with a single pale oil-globule (*o. g.*) of ·21 mm., which in some cases shows a faint, dull-yellowish colouration round the edge. The yolk is colourless, clear, and homogeneous. The punctures of the zona are very evident, and the radial pores are very conspicuous in optical section; the zona has the appearance of being very much wrinkled, as is the case in some ova before fertilization. Examination of flattened ova under a high power shows that whilst the external surface is smooth, the zona is not of uniform thickness throughout, the internal surface being raised into ridges, similar to, but more pronounced and numerous than, those in the unfertilized ova of *Pleuronectes cynoglossus.* This may be due to artificial causes. This observation may, I think, be taken as confirming Raffaele's surmise (*op. cit.*, p. 48) that certain pelagic ova (having a diameter of 1·32 mm., with an oil-globule of ·21 mm.), taken by him at Naples in the summer, belonged to this species. The differences of measurement are insignificant. M'Intosh and Prince (*op. cit.*, p. 847) obtained similar ova at St. Andrews in February and March, so that the spawning season of this form appears to extend over a considerable period in the British Isles.*

* Dr. T. Wemyss Fulton records a ripe female in May, from the mouth of the Forth—(" Spawning and Spawning-places of Marine Food-fishes," Eighth Annual Report of the Fishery Board for Scotland, 1880, pt. iii.).

A single egg (fig. 14) apparently belonging to this species, with diameter 1·31, and oil-globule ·21 mm., occurred in the surface-net in Clew Bay on the 2nd July.

The zona in this specimen exhibits nothing of special interest; the perivitelline space is small; the embryo is little advanced, with about four protovertebræ: no pigment is present; the oil-globule has migrated a short distance towards the posterior region.

Pleuronectes microcephalus (Donov.). The Lemon Dab, or Lemon Sole.

Pl. XLVIII., figs. 19–21; Pl. L., fig. 39.

Ripe females were obtained frequently, yielding an abundance of mature ova. Some which I measured on the 25th June had a diameter of 1·25 mm.,* being thus smaller than those measured by Mr. Cunningham, at Plymouth† (*op. cit.*, p. 15). I endeavoured to fertilize these, but without success. Four hours later they were still translucent and floated buoyantly, whilst in a few a small perivitelline space had appeared, as after fertilization.

Cunningham (*ibid.*) points out that "the external surface of the vitelline membrane shows a number of fine raised ridges forming two systems of parallel lines which cross one another diagonally." M'Intosh and Prince give a figure (*op. cit.*, Pl. I., fig. 18) of part of the zona under a high power, showing a somewhat irregular reticulation of lines, seen as white spaces on the closely dotted surface. The latter condition is more in accordance with my own observations. Examination of the zona in the living egg (fig. 21) certainly gives the impression described by Cunningham, but if it is ruptured and flattened out, it is seen (fig. 20) that the markings are extremely irregular. There are certainly two general systems of parallel lines, but these lines are by no means continuous, frequently ending blindly, converging and diverging, or bending abruptly to continue their course at a different level. Seen from above the markings appear as a line on to which the thickly-set punctures of the rest of the zona do not extend. By tracing the lines to a point where the zona is doubled over so as to present an optical section, it is clearly seen that they are not ridges at all, but sharp grooves indenting the surface of the zona from about a quarter to a half of its thickness, according to the size of the lines, which are of varying widths. In some instances the sides of the grooves are very slightly raised above the general surface level.

By the kindness of Professor M'Intosh I have been enabled to add to my

* Some dead fertilized ova of this species in the tanks here measured from 1·2 to 1·31 mm.

† Mr. Cunningham gives 1·36 to 1·44 mm., "though individual ova may be a little smaller or a little larger." In an earlier paper he gives 1·1 mm. as the diameter of the mature (unfertilized) ovum.

observations from some ova of this species which he is at present developing. I cannot find these markings in ruptured zonæ, from which the larva has escaped, and they are very faint in dead and decomposing ova.

Only a single egg (fig. 19) of this species, with a diameter of 1·25 mm., and showing the peculiar marking of the zona, occurred in the tow-nets, viz. in the surface-net, in Inver Bay, on June 25th.

It is at a stage somewhat in advance of that shown by Cunningham in his figure 7 (*op. cit.*), having a free caudal region about equal to the rest of the body, and a broad marginal fin. Pigment is altogether absent, though black chromatophores are shown by Cunningham in the figure alluded to, having first appeared on the previous day.

Professor M'Intosh pointed out to me long ago that a temperature slightly higher than normal frequently brings about a precocity of pigment, a phenomenon very noticeable in the development of the sprat. This probably accounts for the difference in the condition of pigmentation in Cunningham's ova and my own, though the latter, a single specimen, may perhaps be abnormal. Three days later I found that the larva had escaped, and was darting actively about the vessel, occasionally resting for a time at the surface.

It is now (fig. 39) apparently at a stage between those shown by Mr. Cunningham in figures 8 and 9, and does not altogether agree with his descriptions. The length is 3·98 mm., a little longer than Mr. Cunningham's newly escaped larva. The snout projects boldly, but the mouth is as yet unformed, though the branchial bars are visible. The mid-brain (*m. b.*) is rather prominent dorsally, its greatest height being behind, instead of in front of, the middle of the eye, as in Cunningham's figure 9. The nasal sacs (*ol.*) are apparent just in front of the eyes, which to some extent overlap them. The otocysts, which are omitted in Cunningham's figure 8, are large, of the usual shape, but somewhat upwardly rotated on the hinder ends, and lie a little distance behind the eye. The pectorals (*p.f.*) are considerably developed, they have undergone a partial rotation, and are somewhat in advance of the position at which these organs usually make their first appearance.

The gut is large and tubular. It displays two dilatations close behind the pectoral fins, representing the liver and stomach. The intestinal region of the gut is very ample, and there is a sharp constriction immediately in front of the rectal region (*r.*), which ends blindly short of the margin of the ventral fin, appearing in this respect to be somewhat abnormal. The anus is as yet imperforate, and there is no appearance of an urocyst. The yolk (*y.*) is narrow and elongated, and the space in front of it, spoken of by Cunningham as the venous sinus, is much smaller than in either of his figures. The posterior end of the heart (*h.*) is against the front wall of the yolk. The marginal fins are rather narrow, the dorsal com-

mences just behind the level of the otocyst; the caudal is short and narrow, and almost lanceolate. Pigment is of two kinds, black and grass-green (chrome-yellow by transmitted light). The yellow is generally distributed over the head and the anterior and postero-ventral parts of the yolk-sac. From the otocystic region, dorsal, renal, and ventral-intestinal lines of chromatophores run back to the anal region. The post-anal region is crossed by three pigment bands (*p. b.*), the most anterior of which is rather feebly marked. A few large chromatophores occur on the anterior part of the dorsal fin. Black pigment is found in stellate chromatophores on the top of the head and about the otocyst; antero-ventrally on the yolk-sac, and along the ventral edge of the gut. There are dorsal and post-anal ventral rows of black as far back as the end of the second pigment band, the former reappearing above the third and last band.

Pleuronectes cynoglossus (Linn.). The Pole Dab, or White Sole.

The ova of this species were first obtained by Mr. J. T. Cunningham in the Clyde, and are described by him in a Paper "On the Eggs and Larvæ of Teleosteans" (Trans. R. S. E., pt. I., vol. xxxiii., p. 101). He gives 1·155 mm. as the diameter after the formation of the perivitelline space.

The trawl brought up some ripe females in Donegal Bay on the 26th June. I found that the diameter in the ripe unfertilized egg varied from 1·07 to 1·13 mm. The yolk is clear and homogeneous, and the zona has an appearance of close longitudinal striation. In stained spirit preparations under a high power the striation can be reduced to numerous short line-like markings, lying close side by side, with overlapping ends. They appear to be due to the fact, shown in optical section, that the internal surface of the zona is raised up into numerous minute ridges. This condition, which is met with also in the unfertilized egg of the brill, may perhaps disappear with the formation of the perivitelline space, or may be due to the action of reagents; the striation, however, is as well marked in fresh as in preserved specimens.

CLUPEIDÆ.

Clupea sprattus (Linn.). The Sprat.

The ova of this species occurred in the surface net in Inver Bay on June 25th, and in Clew Bay on the 30th June.

Numbers of young sprats between 2 and 3 inches long occurred in the stomach of Acanthias on the latter occasion.

Clupea harengus (Linn.). The Herring.

A post-larval herring, $1\frac{1}{6}$ inches in length, occurred in the trawl in Birturbuy Bay in the early part of June.

Syngnathidæ.

Siphonostoma typhle (Linn.). The Broad-nosed Pipe-fish.

This species was found to be very common amongst the Zostera beds in Clew and Blacksod Bays on the 2nd and 6th July. A single specimen was taken in the shrimp trawl in Killybegs Bay on the 23rd June. Many of those taken in the Zostera beds presented an exact imitation of the colour of the Zostera. All the males observed carried either well-advanced ova or young. The latter were of different sizes in different parents, some being so far advanced that they readily quitted the parent in the bucket in which they were placed on capture. Ryder has described the development of an American species (*S. fuscum*) (*op. cit.*, p. 508).

Syngnathus acus (Linn.). The Great Pipe-fish.

Abundant in the same locality as *Siphonostoma typhle*, and agreeing with it in the condition of the eggs and young. This species occurred also at Inishboffin and other places, and was obtained whenever the shrimp trawl was worked on weedy ground. Young specimens were occasionally obtained in the surface-net, amongst floating weeds, in Blacksod Bay.

Nerophis æquoreus (Linn.). Snake Pipe-fish.

Abundant in the Zostera beds, on the same dates as the Siphonostoma. Many of the males carried ova more or less advanced. As in Siphonostoma, the colouration, save for the transverse bars, presents an exact mimicry of the surrounding Zostera. The same condition was noticeable in specimens of *Hippolyte varians.*

Nerophis lumbriciformis (Willugh). Worm Pipe-fish.

Specimens of this species occurred frequently. A few males, taken amongst the rocks in Killeany Bay, Aran Islands, carried advanced ova (3rd June).

Unidentified Pelagic Ova.

Species I.—Solea (?)

(Pl. xlix., fig. 26; Pl. l., figs. 34 and 35.)

A single egg (fig. 26) occurred in the surface-net, in Clew Bay, on the 1st July, 1890. The diameter is 1·38 mm. The embryo is somewhat advanced, but has only a short free caudal growth. The zona presents no characters of special interest, and the perivitelline space (*p. s.*) is small. The yolk (*y.*) has a peripheral layer of clear segments or vesicles (*c. v.*), which appear somewhat smaller and more numerous than those of *Solea vulgaris.* A number of oil-globules are present about the periphery of the yolk mass. They are divisible into two sorts:—(1) Very minute globules (*o. g.* 1), arranged in little groups in the immediate vicinity of the embryo, viz. beneath the head and close to the sides of the anterior third of the body, with the exception of one very small group near the posterior extremity. (2) Larger globules of varying sizes (*o. g.* 2) scattered irregularly over the general yolk surface. The lens is fully formed, but the otocysts are as yet not visible. A few small black chromatophores occur on the head; and bright-yellow chromatophores are profusely scattered all over the embryo, and on the parts of the yolk-sac immediately adjacent to the head and trunk. There is no pigment on the rest of the yolk-sac.

Four days later, on the morning of July 5th, the larva was observed to have emerged. On the afternoon of the same day it presented the following appearance (fig. 34). Total length 4·10 mm., of which ·30 mm. is occupied by a precephalic expansion (*f.*) of the marginal fin, to be hereafter described. The post-anal length is 2·10 mm., the anus (*a.*) being thus slightly anterior to median.

The cephalic contour is remarkable. The mid-brain (*m. b.*) is relatively enormous, and projects forward in a blunt point, overhanging the downwardly directed fore-brain (*f. b.*); the cerebral lobes are large and rounded; the pineal sac is scarcely visible, being masked by other structures. The eye is large, and is antero-ventrally directed: its posterior moiety lies behind the hinder end of the optic lobes (*m. b.*),—a very unusual relationship. The cerebellar fold cannot be distinguished, but the hind-brain (*m. o.*) is very large and prominent. The elongated inferiorly concave otocyst (*ot.*) lies close behind the eye. No mouth is visible, but the branchial bars (*b. b.*) and slits can be distinguished. With the protrusion of the brain, the anterior end of the notochord is carried forward. A large vesicular expansion (*f.*) of the marginal fin extends forwards over the head, in front of which it projects like a large bladder. By the aid of dorsal (fig. 35) and profile (fig. 34) views its relationships can be pretty well made out. The

greatest width is in front of the mid-brain; and the posterior limit is about the level of the crystalline lens. Ventrally it is dilated below the free part of the mid-brain, the inferior contour running from a point a little above the cerebral lobes to the top of the eye. A short median fold is directed downwards in front of the pineal region. The heart (*h.*) is large and active. Its hind end rests against the yolk (*y.*), which is reduced and pyriform, anteriorly blunt, and still exhibits very clearly the ovoidal peripheral segments (*c. v.*) The smaller oil-globules have disappeared; the larger ones are scattered over the general yolk-surface, principally at the posterior end. A few largish ones at the front of the yolk very probably represent the coalesced smaller globules.

The pectoral fin (*p. f.*) is fairly large, but as yet simple; it lies on the dorsal wall of the abdomen, with obliquely rotated base, a little behind the level of the front of the yolk mass. The gut is large and perforate except at the anus. It is bent down in the middle of its length, just in front of which point occurs a large dextral sac (*s.*) apparently representing the cardiac dilatation of the stomach. Posteriorly the rectum (*r.*) descends obliquely towards the edge of the marginal fin, which the imperforate anus does not quite reach. The long narrow urocyst (*u.*) lies against the posterior wall of the rectum. The notochord is multi-columnar with largish cells, and is rather stout. From the pre-cranial vesicle (*f.*) the dorsal marginal fin rises in a gentle ascending curve till it reaches a point a little behind the pectorals, where its height is ·48 mm., the total height of body with yolk and fin being 1·08 mm. Thence the fin descends gradually to the broad rounded caudal lobe, in which embryonic fin rays have appeared. The ventral fin has about the same dimensions as that part of the dorsal which is opposite to it. Just behind the anus the trunk is about ·24, whilst the dorsal and ventral fins are each about ·39 mm. in height. The pre-anal fin, extending nearly half-way along the yolk, is somewhat broader. The anterior three-quarters of the head and trunk is covered with profuse dendritic pigment of a bright gamboge-yellow colour; there is a very bright patch (*p. b.*) at the end of this region, from which ramifications extend on to the dorsal and ventral fins, anastomosing with a large chromatophore on each fin. The rest of the trunk is little pigmented. Round yellow chromatophores are distributed over the general surface of the yolk-sac, dendritic pigment covers the pre-cranial vesicle and pre-anal fins, and there are six and four large patches along the margins of the dorsal and ventral fins respectively.

A few small stellate black chromatophores occur on the fore- and mid-brain, about the commencement of the notochord, over the yolk-sac and along the ventral edge of the hinder third of the gut. Black pigment also occurs in faint lines along the sides of the pre-cranial vesicle. No black pigment occurs on the eye.

I cannot say anything definite as to the age of this larva, except that it is more than six hours old.

It is difficult to refer this specimen definitely to any species. The measurements of the ova of *Solea vulgaris* given by various authors are somewhat conflicting. M'Intosh and Prince (*op. cit.*, p. 848) give ·045 in. (roughly about 1·125 mm.). A number which I pressed from a female and artificially fertilized measured between 1·31 mm. and 1·40 mm.; and others taken in the tow-nets at St. Andrews in June, 1890, varied between 1·25 mm. and 1·28 mm. Cunningham's measurements (Reproduction and Development of Teleostean Fishes, p. 18) are 1·41 to 1·51 mm.*

Thus there seems to be in the single species a very great variation, perhaps to some extent governed by local conditions, as Cunningham's specimens, from Plymouth, are much larger than any that have come under our notice here.

Of Raffaele's soles, the ova of his undetermined species, 1. Solea (?) (*op. cit.*, p. 63), approaches ours most closely in dimensions, being 1·4 mm. Solea, sp. A and B, are respectively 1·06 mm. and 1·23 mm. in diameter (pp. 43–45).

In the character of the vesicular layer of the yolk my egg differs from *Solea vulgaris*, as described and figured by M'Intosh and Prince, and as observed by myself at this place, in that the segments appear to be smaller and more numerous; but Cunningham (*op. cit.*) has shown that in this matter *Solea vulgaris* is subject to individual variation. In my form the segments persisted some time after hatching as conspicuous objects, a condition different to that indicated by M'Intosh and Prince.

As regards the oil-globules, the presence of groups of minute globules along the sides of and under the embryo is a marked character of *S. vulgaris*, and of Raffaele's sp. A and B, whilst it is wanting in his sp. 1.

The presence of larger globules over the general yolk surface is peculiar, as though M'Intosh and Prince's figure (*op. cit.*, Pl. II., fig. 11), shows that in *S. vulgaris* larger globules are present in the later stages of development (doubtless by coalescence of smaller), yet in that form they are grouped with the smaller ones, mostly about the ventral surface of the embryo, a condition which is not found in our form even after extrusion. The colour and arrangement of the pigment is very different from that of *S. vulgaris*.†

The egg of *Solea variegata*,‡ described by Cunningham, approaches this form very closely in dimensions, being only ·02 mm. smaller, but differs in the character of the oil-globules.

* In his "Treatise on the Common Sole," Plymouth, 1890, p. 84, this observer gives the dimensions as 1·47 to 1·51 mm.

† M'Intosh and Prince (*op. cit.*) describe and figure the pigment of the larval *S. vulgaris* as a stone-grey, a condition in accordance with my own observations. Cunningham ("Treatise on the Common Sole," pl. XVI., figs. 3 and 4) figures the pigment as a brilliant orange, and does not allude to the work of previous observers.

‡ In his recent work, Cunningham gives the dimensions of this egg as 1·28 to 1·36 mm., and figures both eggs and larvæ.

The remarkable forward projection of the mid-brain in the larva seem to separate it from any other known form.

M'Intosh and Prince (*op. cit.*, p. 851), call attention to a dorsal prominence of the optic lobes, imparting a hooded aspect to the head of a larval sole four days old, and Raffaele's figure of the larva of *Solea*, sp. A, indicates a condition somewhat approaching that in our form. Sp. A also approaches ours in having a "lobo cefalico rigonfio" of the dorsal marginal fin, and the colour and character of its pigment appear almost the same. But sp. A not only has a much smaller ovum, but is much less elongated in its larval stage. M'Intosh and Prince (p. 850) mention a vesicular process over the brain in one example of *S. vulgaris*, but regard it as abnormal.

The spawning period of Raffaele's species A and B extends over autumn, winter, and spring, and that of his species 1 from June to August.

Cunningham gives March, April, and May as the spawning period of *S. vulgaris*, an observation which presumably refers to southern waters. That the period may be extended on the Scottish coasts is apparent, from the fact that a ripe female was obtained by Professor M'Intosh on August 1, 1884.

During the six weeks with which this report deals we obtained a considerable number of soles from time to time, but they were all spent, males and females alike. A specimen of *Solea variegata*, obtained early in July, was also spent. *Solea lutea* appeared to be ripe during this period, but I have no accurate observations at present on its ova, as taken from the female, though I am inclined to regard a much smaller sole-like egg (species II. of this series) as belonging to that form.

The form before us may possibly be a monstrosity of *Solea vulgaris*, but it is difficult to regard it in that light, as it differs at once from that species in so many characters—characters which bring it nearer to the Mediterranean species A.

Solea lascaris, the lemon sole, is regarded by Day as identical with *S. impar*, one of the species examined by Raffaele (species A or B ? *op. cit.*, p. 43). The only other sole recorded from the west coast of Ireland is *S. greenii*,* a deep-water form, of which Mr. G. C. Bourne obtained a ripe female in July, 1889.

Species II.—**Solea lutea** (?) (Risso).

Pl. XLVII., figs. 9 and 10. Pl. LII., figs. 46–52.

These small pelagic ova were obtained abundantly in the surface nets in Blacksod, Inver, Donegal, and Clew Bays, from the 15th June to the 8th July.

In appearance they exactly resemble Cunningham's figure of the pelagic egg, which he attributes, doubtless correctly, to *Solea variegata* (*op. cit.*, Pl. III., fig. 15, p. 23), but the dimensions are smaller. The diameter is from ·775 to ·835 mm. (that

* Discovered by Mr. Green in the "Flying Fox" Expedition. 1889.

of *S. variegata* is 1·36 mm.). The shape is usually spherical, but some are ovoidal, having a long and short diameter of ·835 and ·775 mm. respectively. The numerous small oil-globules (*o. g.*) are restricted to the vegetative hemisphere, both in early (fig. 10) and advanced (fig. 9) stages, and are never aggregated at the sides of the embryo or under it, as in *S. vulgaris*.

The globules are much larger than those in the unfertilized egg of *S. vulgaris*, and are quite colourless. There is a cortical layer of yolk segments (*c.v.*) very conspicuous in the early ova,* but becoming less so as development proceeds, though they are still visible in the early larva (fig. 46).

Raffaele (*op. cit.*, p. 64) describes and figures a pelagic egg, his undetermined species 2, which presents the closest possible resemblance to this form. Its diameter is ·75 mm., thus differing very slightly in size from our form. It occurs at Naples sparingly in January; I think it more than possible that the two forms are identical, the resemblances outweighing the slight discrepancy in size.

The period of development *in ovo*, in the form before us, occupies about five days. The embryo is at first colourless, but pigment of a faint yellow colour, black by transmitted light, appears with the first development of the free caudal region (fig. 9).

It occurs in small rounded chromatophores on the top of the eyes and head, in a double line along each side of the trunk, and over the general surface of the yolk-sac. At this stage the otocysts have not appeared, and the lenses are not invaginated.

As development proceeds the pigment gains in brilliancy, becoming in the larva a bright-orange, brown by transmitted light.

The larva emerges at an early stage of development (fig. 46). The yolk (*y.*) is large and globular, there is no mouth, and the fore-brain is bent down to the anterior extremity of the yolk-sac. The olfactory apparatus cannot be made out; the eyes are of moderate size, and pigmentless, save for a few chromatophores over the retina. The otocysts (*ot.*) are small and oval, and remote from the eye. The contour of the head is rounded, and the medulla rises somewhat above the plane of the top of the mid-brain. The cerebellum is somewhat large, but the pineal body is not visible.

The heart (*h.*) lies immediately behind the eyes, in a depression of the top of the yolk. It is partially constricted into auricle and ventricle, and is, as usual, directed to the left.

* These segments appear first at the animal pole, beneath the blastoderm, and extend gradually over the whole periphery of the yolk. A very early ovum, which I obtained at St. Andrews on the 30th of July, showed the oil-globules mostly arranged in a ring at the rim of the vesicular layer, which did not quite reach the equator. Their subsequent disposition may be in some way due to the extension of the segments.

The gut is somewhat large and tubular, except in the rectal region; it extends below the notochord a short way beyond the yolk; the narrow cord-like rectum (*r.*) descends vertically to the marginal imperforate anus (*a.*), at a short interval from the hind-wall of the yolk-sac. The oil-globules (*o. g.*) are, as a rule, restricted to the posterior region of the yolk, occupying the ventral and ventro-lateral surface of that region, having, as is frequent, undergone a migration backwards from their original positions.

The marginal fins are somewhat narrow, the dorsal and ventral being about ·12 mm. each, except at the anterior extremity of the ventral, which descends on to the postero-ventral border of the yolk-sac, becoming thus somewhat deeper. The dorsal commences at the otocystic region; the caudal is short and rounded, with no embryonic rays. The pectoral fins have not appeared. The notochord is multi-columnar, with small cells.

The pigment, now a bright-orange colour (brown by transmitted light), occurs in small chromatophores over the head, along the back, and ventral post-anal region, over the yolk-sac, and on the posterior part of the gut, and at the anus. It forms a conspicuous bar (*p. b.*) across the trunk at the commencement of the posterior third of the total length. Chromatophores occur also on the dorsal, and sparingly along the edge of the ventral fin.

The total length at this stage is 2·02 mm., of which the pre-anal region occupies ·895 mm., the anus (*a.*) being slightly anterior to median. It is probable that there is slight variation in the length of the larva on emerging.

A specimen about a day old (fig. 47), has a total length of 2·14 mm., the increase being entirely in the post-anal region. The yolk is slightly reduced.

At about two days old (fig. 48) the total length is the same as in the last stage. The yolk is further reduced, and the oil-globules are fewer in number. The snout is more forwardly directed, and the pineal body is conspicuous. The mid-brain has gained slightly in dorsal prominence. The otocysts are larger and ventrally convex. They have undergone a slight upward rotation on their posterior ends, and, by the shortening up of the hind-brain, are carried nearer to the eye.

The invagination of the stomatodeum has commenced. The pectorals have appeared as semicircular folds of epiblast (their bases parallel to the notochord), midway between the snout and the anus. The gut is dilated more conspicuously in the region of the future stomach (*s.*), and its thickened tubular character has extended some way down into the rectum. The chomatophores have now become stellate, and another pigment bar (*p. b.*) has appeared across the trunk midway between the anus and the bar noticed in the newly-hatched larva. The chromatophores of the yolk-sac are fewer, but larger than formerly, and those on the edge of the ventral fin have disappeared. The dorsal fin has extended forward to the mid-brain, and is much expanded, as are the ventral and short pre-anal fins.

Two days later (fig. 49) the yolk is still further reduced, and very few oil-globules remain. The total length is now 2·38 mm., the increase being still confined to the post-anal region. The mid-brain (*m. b.*) is more prominent dorsally, and the mouth (*m.*) forms a deep pit below the eyes. The lower jaw is short, and downwardly directed.

The otocysts are much larger. The gut is a little bent downwards in the middle of its course, and the rectum (*r.*), except a very short distal portion, is expanded and tubular. A considerable interval, due to the absorption of the yolk, now occurs between that structure and the rectum. The pectorals (*p. f.*) have increased in size; they are fan-shaped, and their bases are further forward than before, and have undergone a considerable rotation in the usual direction. The arrangement of the pigment is somewhat altered. The earliest pigment bar (*p. b.*) has been carried backwards with the elongation of the post-anal region. In front of it are three large pectinate patches along the dorsum, the most anterior lying above the anus. Similar ventral patches opposite the two dorsal ones, almost form two anterior bars. The anterior bar noticed in the larva of four days has disappeared. Large patches, varying in individuals, occur along the dorsal fin near its margin, the largest being in the anterior region. Lengthened patches occur along the ventral near its base, principally in the posterior region. In the specimen figured the dorsal does not extend so far forward as in the earlier stages shown. The pectorals are pigmented, and embryonic fin-rays have appeared in the caudal fin.

In older stages (shown in figures 50 and 51) the prominence of the mid-brain (*m. b.*) is still more marked; the heart is advanced, and the gut is longer and slightly convoluted; the anus is perforate; and a long urocyst (*u.*) has appeared behind the rectum. The pectoral fins are lobate and rayed. The otocysts (*ot.*) are larger, and somewhat rectangular and inferiorly concave. They are now close behind the eyes. There are no oil-globules left in the reduced yolk mass. A marked angulation of the dorsal fin occurs behind the pectorals.

The post-anal region of the trunk is very attenuated, and the marginal fins are much expanded.

Black pigment has commenced to appear in the eyes; and further changes have taken place in the arrangement of the yellow pigment.

The total length is now 2·98 mm., the increase being still almost entirely confined to the post-anal region.

The development of the jaw apparatus is much advanced, the lower jaw (*mk.*) projects boldly forward, and is freely moveable. The hyoid and branchial arches are easily seen, but the latter are not as yet pectinate. The heart (*h.*) is closed and perfect. The gut is much lengthened and convoluted, and the liver (*l.*) is seen as a lobe-shaped body in the anterior part of the abdomen. There is a

conspicuous rectal valve (*r.v.*). The clavicle (*cl.*) is conspicuous in front of the very large fan-shaped pectorals (*p.f.*), the rotation of which is now complete. The eyes are black at this stage. The caudal fin has become somewhat lanceolate, and the dorsal sends down a narrow strip in front of the mid-brain (*m. b.*).

The post-larval condition (fig. 52) is reached in eight or nine days. There is no great advance from the last stage, except that the liver (*l.*) is larger, and the gut more convoluted; whilst the dorsal fin is further expanded in the anterior region.

No black pigment has appeared except in the eyes, but the yellow pigment has become somewhat greenish. The total length is from 2·98 to 3·10 mm., there is a slight increase in the pre-anal length, which is now ·96 mm. This is an extremely hardy species; with very little attention they were easily reared in small vessels to the post-larval condition. It is interesting that Professor M'Intosh obtained two eggs, apparently identical with these, in St. Andrews Bay in the early part of July of this year, and another occurred on the 30th of that month.

From the characters of the egg and larva I am inclined to think that the parent species is *Solea lutea.* This is, of course, mere conjecture, but it is perhaps permissible in view of the many sole-like characters that are met with.

The combination of a cortical layer of yolk segments with numerous small oil-globules is, as far as I know, confined to the eggs of various species of *Solea* and to Raffaele's undetermined species, No. 2, which is probably identical with this form. I know that *Solea lutea* breeds about the time these eggs were obtained, from having found a nearly ripe female of this species in Galway Bay on the 2nd June. Unfortunately, having much other work on hand, I did not examine its ova minutely, and can only say that they were very small.

Species III.—**Motella-like.**

Pl. XLVII., fig. 11.

Several specimens of this small pelagic egg were taken in the surface-net in Blacksod Bay on the 14th and 15th June.

The diameter is ·66 mm.; the zona shows no peculiar features; the yolk (*y.*) is clear and homogeneous, and there is a single oil-globule (*o. g.*) in the usual position, exhibiting a pale greenish-yellow colouration, ·14 mm. in diameter.

Of two ova examined one contains an early pigmentless embryo, from the sides of which faint transverse striæ extend outwards over the yolk-sac for a little distance. In the anterior region the yolk is a little separated from the yolk-sac, and a faint stellate striation occurs on the upper surface near the oil-globule.

In the other specimen (fig. 11) the embryo is more advanced, having a short

free caudal region, and exhibits no striation of the yolk-sac, which may probably be attributed in the other to ill-health.

Five small black chromatophores occur over the oil-globule, and the yolk-sac is very sparingly decorated in a similar manner. Small stellate black chromatophores occur on the top of the brain, and in a row along each side of the dorsum, except in the free caudal region, where there is a single median dorsal row. There is a prominence (*l. s. o.*?) on either side of the anterior region of the body, which perhaps represents a lateral sense organ.

These ova were lost on the 17th June, by the upsetting of my aquaria in a heavy roll, and I never obtained any other specimens.

This form is rather smaller than the egg of *Motella mustela*, with a rather larger oil-globule, the colouration of which is distinctive. The pigmentation of the embryo is also more precocious than in *M. mustela*, and is differently arranged (*cf.* Brook, "The Development of *Motella mustela*," *loc. cit.*). It agrees with the egg of *M. tricirrata* in the arrangement of the pigment, and in the presence of colouration in oil globule, but differs in size, the egg of this species, according to Raffaele (*op. cit.*, p. 37), having a diameter of ·75 mm., with an oil-globule of ·218 mm.

It seems probable that the present form is a Gadoid, possibly *Motella cimbria.*

Species IV.—**Ctenolabrus rupestris.** (?)

Pl. xlviii., figs. 23 and 24. Pl. xlix., figs. 28–30.

These pelagic ova occurred in the surface-net, in Blacksod Bay on the 15th June, and in Inver Bay on the 20th and 25th June. They were not abundant.

The egg is spherical, with a diameter of ·835 mm., and the zona is thin and minutely pitted, the yolk translucent and homogeneous. There is no oil-globule. The perivitelline space is small. The younger stages exhibit no distinctive characters. Black pigment appears at the time when the free caudal region becomes noticeable (fig. 23), and is arranged in a row of small chromatophores along each side of the body, except in the caudal region. A few very minute pigment dots occur at intervals between the outer rows, and there are several larger chromatophores on the top of the brain.

A specimen obtained on the 20th June exhibited the first formation of the embryonic shield. Two days later the embryo was far advanced (fig. 24) having a free caudal region equal to the rest of its length. The body is very slender. The crystalline lens is fully formed; the heart beats actively. The otocysts (*ot.*) are visible as small ovoidal sacs, with otoliths, remote from the eye. The lateral row of black chromatophores extends some way along the free caudal region.

The structure of the notochord (*no.*), unicolumnar throughout at this stage, is clearly visible, and there is a broad marginal fin.

I was only successful in hatching one egg of this species, viz. one obtained on the 25th June. I examined the larva on the 29th June (figs. 28 and 29), when it appeared to be somewhat older than Agassiz and Whitman's *C. adspersus* of twenty-four hours (*op. cit.*, Pl. IX.). The total length is 2·855 mm. The pre-anal length is 1·37 mm., and there is an interval of ·62 mm. between the yolk and the anus; the post-anal length is 1·485 mm.

There are five pairs of lateral sense organs (*l. s. o.*) as in *C. adspersus*, of which the first pair occupies the same position as in the American species, viz. between the eyes and otocysts. The three remaining pairs, however, lie further back than in the newly hatched *C. adspersus*, the second pair lying between the end of the yolk and the anal region, whilst the last three are placed at equal distances along the post-anal region. They represent probably some of those more numerous organs shown by Agassiz and Whitman (*op. cit.*) in a larva some hours after hatching (Pl. IX., fig. 33). The third and fourth pairs are not quite symmetrical.

The greater part of the head projects forward in front of the yolk, terminating in a blunt snout. There is as yet no mouth. The pineal is easily seen, as are the precocious nasal sacs (*ol.*), from which the nasal valves (*n. v.*) already project clear of the contour of the head (fig. 30). The cerebellar fold is small. The otocysts (*ot.*) are sub-circular and small, and as yet remote from the large unpigmented eyes. The pectorals (*p. f.*) are visible as largish, semicircular folds of the lateral epiblast about half-way between the snout and anus.

The gut is slightly dilated below the pectoral fins. It runs back as a thick-walled tube below the notochord to the anal region, at which point it sends down a solid translucent cord-like limb (*r.*) almost vertically, to the marginal and imperforate anus (*a.*). The urocyst is not visible.

The notochord (*no.*) presents the same remarkable structure as in *C. adspersus*. Its anterior third, *i. e.* the part overlying the yolk, is unicolumnar. At the commencement of the middle-third two cells begin to make their appearance in the same plane of transverse section, a condition which persists as far back as the caudal extremity, where, as is frequently the case in larval fishes, the notochord is irregularly unicolumnar. The cells of the anterior unicolumnar region have not the same bubble-like structure as is met with in the herring and sprat.

The dorsal marginal fin rises a little behind the otocyst and gradually attains its greatest height, a little more than that of the body, opposite the anus. The ventral fin is of the same dimensions as the dorsal, both tapering insensibly into the short and almost lanceolate embryonic caudal fin. Anteriorly the rectum (*r.*) cuts off a pre-anal segment (*p. a. f.*) from the ventral marginal fin, the margin of

which is incurved at the anus (*a.*). Pigment is confined to a double dorsal line of small black chromatophores, extending from the snout backwards along the anterior two-thirds of the body.

I think that these eggs and larva may be with little doubt referred to *Ctenolabrus rupestris.*

The egg is very little smaller than that of *C. adspersus* (which measures ·85 to ·92 mm.).

The larva is also a little smaller. It will be seen from Agassiz and Whitman's account (*op. cit.*, p. 18) of *C. rupestris*, that in the pigment, contour of the larva, and sense organs, the two species present close resemblances, whilst the notochord, a feature of importance, has the same peculiar structure in both. That *C. rupestris* occurs in the neighbourhood where these ova were obtained is apparent from Day's account of their habitat (*op. cit.*, vol. i., p. 265). I myself obtained some young specimens, but was not so fortunate as to get any sexually mature. Day mentions a female full of spawn taken at Dublin in June. The American species spawns from May to July.

These fish seem to be known (in common with the rest of the Labridæ) as gunners on the Mayo coast.

Species V.—**Coris-like.**

(Pl. XLVIII., fig. 16; Pl. LI., figs. 43–45.)

These ova occurred sparingly in the surface-net on the 20th June in Inver Bay, and on the 7th July at the Bull's Mouth, Achill Island.

The diameter is from ·805 mm. to ·835 mm., and there is a single colourless oil-globule of ·15 mm. In its early stages it is not easily distinguished from a slightly smaller ovum (species VIII.).

The shape is spherical (fig. 16), and the zona (*z. r.*) presents no feature of special interest. The perivitelline space (*p. s.*) is small, and the yolk (*y.*) is colourless, translucent, and homogeneous.

I have no observations on the development *in ovo*. The larva emerged on the 23rd from an egg taken on the 20th June.

The larva (fig. 43) is elongated. The total length (including the yolk and oil-globule) is 2·44 mm., the anus being slightly anterior to median (1·13 mm. from anterior end of yolk-sac). The flexure of the brain is not so apparent as in most early larvæ (from pelagic eggs), as the elongated yolk (*y.*), having the oil-globule (*o. g.*) at its anterior extremity, projects forward in front of the snout, thus to some extent preventing the flexure. The perforated region of the gut extends under the notochord some way behind the yolk, from which the narrow solid rectum (*r.*)

is separated by a considerable interval. The imperforate anus (*a.*) is marginal. There is a small urocyst (*u.*) in the usual position.

The eyes are of moderate size, unpigmented. The pineal (*pn.*) is visible; the cerebellar fold is small. The otocysts (*ot.*) are small, and somewhat conical dorsally, and as yet remote from the eye. The pectorals have not appeared. The dorsal marginal fin commences behind the otocysts, and reaches its greatest height, about ·18 mm., a little behind the anal region. The ventral marginal, slightly less than the dorsal, is indented towards the anus, as is the pre-anal segment (*p. a. f.*). The caudal is broad and rounded, and slightly spatulate at this stage.

The pigment is all black, and is confined to the head and trunk. Largish stellate chromatophores are distributed sparingly and somewhat irregularly over the anterior two-thirds of the dorsal surface. A small chromatophore marks the hind-wall of the urocyst. A little behind the last dorsal, there are two stellate chromatophores on the ventral edge of the body, and a few small stellate chromatophores occur ventrally and laterally in the extreme caudal region.

A day later the larva (fig. 44) is only 2·38 mm. in total length. This decrease is due to the partial absorption of the yolk and withdrawal of its anterior extremity, with the oil-globule, to a point in rear of the fore-brain. The same cause has operated to increase the downward flexure of the brain (a condition the reverse of that which is met with in the development of most teleostean larvæ), thus further decreasing the pre-anal length, which is now only 1·01 mm.

The post-anal length has, however, gained ·06 mm. The yolk is now bluntly ovoidal. The gut shows a slight dilatation in the middle of its length (*s.*), and its tubular region extends a little further into the rectum. The pectorals (*p. f.*) have appeared in the usual position; they are as yet very small, little more than prominences of the lateral epiblast. A great deal of the pigment noticed on the previous day has disappeared; the head is altogether destitute of it, and the dorsal chromatophores are fewer in number, whilst some of them appear to have migrated to the lateral region. The extreme posterior end of the caudal region is slightly upturned, and the subnotochordal pigment is now dendritic, and extends on to the marginal fin. Embryonic caudal fin rays have appeared. The heart at this, as at the previous stage, occupies the usual position, and beats actively. The structure of the notochord (fig. 45) is somewhat characteristic. The cells (vacuoles) are large, and sometimes one, sometimes two, or even three occur in the same plane of transverse section. I was not successful in rearing this species to an older stage.

The ova and larvæ of this form present a remarkable resemblance to those of *Coris julis*, *Coris giofredi*, and *Julis turcica*, as described and figured by Raffaele (*op. cit.*, p. 35). Raffaele's ova, however, are smaller, having a diameter of

60–70 mm., with an oil-globule 16–18 mm. *C. giofredi* is regarded by Day (*op. cit.*, vol. i., p. 269) as a synonym of *C. julis.* Hoffman (*op. cit.*, p. 11) describes the ovum of *Julis vulgaris* as having a diameter of ·75 mm., with an oil-globule of ·15 mm., whilst the newly-hatched larva measures 1·77 mm.

Coris julis is the only one of these species that is known to be British, and it does not seem to have been recorded from Ireland. Centrolabrus, of whose development nothing is known, appears to be fairly abundant on the west coast.

I am inclined to regard this form as belonging to some member of the Labridæ, and closely allied to Coris. The structure of its notochord presents considerable resemblance to that of Ctenolabrus. *Mullus surmulletus* and *M. barbatus* (see Raffaele, *op. cit.*, pp. 20–22) are the only other forms which present any close resemblance to this in their earlier stages, but, besides differences of dimensions, there is in their ova a layer of cortical yolk segments, and the anus in the larva is nearer to the yolk.

Species VI.

(Pl. xlviii., fig. 17.)

This species is represented by only a single example, which was taken in the surface-net in Inver Bay on the 25th June.

The diameter is 1·13 mm., and there is a single oil-globule (*o. g.*) of ·21 mm. The yolk is clear and homogeneous, and there is no colouration of any sort. Whilst agreeing with another unidentified egg, species VII., in measurements, it is at once distinguished from it by the large size of the perivitelline space (*p. s.*), and by the entire absence of pigment at a somewhat advanced stage.

My observations deal only with the stage shown in fig. 17. The embryo is about 1·14 mm. long, of which ·30 belongs to the precaudal region. The eyes are large. I could not make out the otocysts, or the heart. The oil-globule is at the posterior end of the yolk (*y.*), which is ·66 mm. long and ·93 mm. broad.

In the presence of a single oil-globule and a large perivitelline space this egg approaches that of the pilchard (see Raffaele, *op. cit.*, p. 55, and Cunningham's later Paper, p. 43), but differs from it in dimensions and in the absence of the reticulation of the periblast, which is characteristic of clupeoid ova.

Species VII.

(Pl. xlviii., fig. 18; Pl. xlix., figs. 25, 25*a.*)

A few ova, which appeared to belong to the same species, at the same stage of development, occurred in the surface-nets in Inver Bay on the 25th June.

The diameter varies from 1·07 to 1·13 mm.; and there is a single colourless oil-globule, ·15–·21 mm., occupying the usual position at the uppermost pole. The zona presents no features of special interest. The yolk is clear and homogeneous, and the perivitelline space is small.

The embryo at this stage (fig. 18) has a short, free caudal region bent up over the yolk. The otocysts (*ot.*) have appeared as small round sacs, with a double outline, in the usual position. The head and eyes are entirely unpigmented, but a number of minute black pigment dots extend along the trunk on either side of the notochord from the otocysts to the posterior extremity.

A few larger black stellate chromatophores occur over the oil-globule.

Development appears to be slow, and the species appears to be rather delicate. None of these eggs hatched, and only one survived till the 29th June.

The egg then lay at the bottom of the vessel, a phenomenon which I have frequently noticed in advanced ova reared in confinement in this laboratory (*e.g.* ova of sprat, gurnard, &c.), and one which appears to be in no way attributable to ill-health, as the larvæ emerge and are not appreciably less robust than their fellows. That it is not due to a change in the specific gravity of the water is proved by the fact that it occurs even in continually running water of the same specific gravity. That moribund pelagic eggs should sink is easily intelligible, but it is hard to understand why this should also happen to perfectly healthy specimens. It is possibly brought about, in some instances, by the adherence to the zona of particles of dust, &c., which find their way into the aquaria; but appears to be a regular feature of development in some species, *e.g. T. vipera* (*cf.* Raffaele, *op. cit.*, p. 30). The embryo (fig. 25) now appears almost ready for extrusion. The free caudal region is equal to the rest of the body. The eyes are large, and the otocysts have increased in size, and are vertically elongated, but as yet remote from the eyes. The pectorals (*p.f.*) have appeared as small semicircular folds in the usual position. The heart (*h.*) is large, and beats actively. The notochord (pl. XLIX., fig. 25*a*) is stout, and its cells show a definite arrangement into a dorsal and ventral series, the bases to some extent interdigitating, but never approaching the cuneiform condition. The gut is large and perforate, and shows two dilatations in the region of the pectoral fins. It is also slightly expanded near the posterior extremity. The anus appears to lie just behind the yolk. The yolk is still large, and nearly spherical, the oil-globule (*o. g.*) now occupying a posterior position, in a well-marked periblastic pocket. A narrow marginal fin is visible in the free caudal region of the trunk. The cephalic integument and the whole of the surface of the yolk-sac (*y. s.*) is studded with minute tubercles, very conspicuous in profile.

I have noticed a similar condition in individuals of several species (*e. g. Callionymus lyra, Clupea harengus*, &c.). It is sometimes transitory, as in an early cottoid

larva, but it may more usually be looked upon as an indication of approaching moribundity.

The pigment is remarkable at this stage (fig. 25). It is of two colours:—(1) A deep bluish-black, perhaps the "nero violacee" of Raffaele, distributed in rounded chromatophores along the top of the head and dorsum (except the posterior fifth), and more sparingly in the renal region and over the oil-globule. (2) Bright reddish-brown, appearing much the same by reflected and transmitted light, very thickly scattered in small chromatophores all over the head and trunk, except the posterior fifth, where it is confined to the dorsal and ventral regions; it is less abundant on the eyes, and there are two small chromatophores, with the black, over the oil-globule. A little of this reddish pigment also occurs on the part of the yolk immediately adjacent to the head.

These ova present a close resemblance both in dimensions and pigmentation, to those of *Hemitripterus americanus*, identified by Agassiz and Whitman from a series of young forms obtained in the tow-nets.

The Scorpænidæ, to which Hemitripterus belongs, are only represented on the Irish coast by *Scorpæna dactyloptera* (a few specimens from deep water),* and *Sebastes norvegicus*, which is also rare.

The ova of the former probably resemble those of the Mediterranean species described by Raffaele, which adhere together in masses and are destitute of oil-globules, whilst Sebastes is a viviparous form.

Our ova also present some resemblances to those of Sargus and Box, described by Raffaele (*op. cit.*, p. 23), who remarks that they spawn all the summer. Very little information as to the breeding season of the British Sparidæ is forthcoming, Day's conjecture (*op. cit.*, vol. i., p. 37) that *Pagellus centrodontus* spawns in the winter months being probably due to a misconception of the rate of growth of the young.

Species VIII.

(Pl. XLIX., fig. 27; Pl. L., fig. 36.)

This pelagic egg occurred in the surface-net in Blacksod Bay on the 14th, and in Clew Bay on the 30th June.

It is spherical, with a diameter of ·775 mm., and a single colourless oil-globule of ·14 mm.

At the stage shown in fig. 27 the embryo is fairly advanced, but as yet the free caudal region is short. Small, rather pale yellow chromatophores occur sparingly over the general surface of the yolk sac, very abundantly over the

* The young of this species were obtained in considerable numbers, in 80 fathoms, off the Skelligs in August, during the latter part of the cruise of the "Fingal."

oil-globule, and along the sides and on the head of the embryo, but less abundantly on the dorsum. A few small black chromatophores occur along the sides and on the head, and at intervals over the yolk-sac.

About twelve hours after hatching (fig. 36) the total length is 2·68 mm. The snout projects boldly in advance of the yolk. The olfactory apparatus (*d.*) is conspicuous; the eyes are large, but exhibit no black pigment as yet. The otocysts (*ot.*) small, and inferiorly conical, lie someway behind the eye. The pectorals (*p.f.*) have appeared, but are very small. The gut is dilated below the pectorals, and is tubular, and somewhat broad posteriorly; it projects beyond the yolk, and terminates blindly below the notochord at a distance of ·955 mm. from the snout. The yolk (*y.*) is ovoidal, with postero-ventral oil-globule; the notochord (*no.*) is somewhat stout, and multi-columnar, with large cells.

The marginal fins are very broad, reaching their maximum a little anterior to median. The dorsal rises from the top of the mid-brain, and exhibits a remarkable angulation above the otocysts.

The black pigment has altogether disappeared, whilst the yellow has gained in brilliancy. It is now a vivid orange by reflected, and brownish yellow by transmitted, light. It covers the whole of the head and trunk in a network of dendritic chromatophores, except the extreme posterior region, which is devoid of pigment, and a broad bar about the middle of the post-anal region, which is almost equally so. The oil globule (*o. g.*) and the adjacent parts of the ventral fin and yolk-sac, as well as the anterior region of the yolk-sac, the pectoral fins, and that part of the dorsal fin which lies below the angulation previously noticed, are also brilliantly pigmented.

I cannot say much as to the affinities of this form. The dimensions of the ovum agree well enough with *Centropristis hepaticus* (*cf.* Raffaele, *op. cit.* p. 19), but the larvæ and the two forms present obvious differences.

Species IX.

(Pl. xlix., fig. 33.)

On the 13th June off Cleggan Head, near Innishboffin, and off the Bills, and on the 5th July in Keel Bay, Achill Island, a number of large pelagic ova were taken in the surface-net. I have referred these to a single species, as, though the variation in size between the largest and smallest is considerable, between intermediate specimens it is very slight, and I could see no other character to distinguish them from each other.

The egg is spherical, with a diameter of 1·49–1·64 mm., and there is a single colourless oil-globule of ·24–·30 mm. It is thus the largest egg of this series, being considerably larger than that of the grey gurnard.

The zona is thin, the yolk clear and homogeneous, and in the early stages the perivitelline space is small, and the whole egg is extremely translucent.

The species appears somewhat delicate, as none of the ova hatched, although several reached a late stage of development. They showed a tendency, at a comparatively late stage, to sink to the bottom of the vessel, and, after continuing to develop there for some time, became opaque and died. It would appear that the larva escapes in a more advanced condition than is usual in pelagic forms. The yolk is greatly reduced, leaving a very large perivitelline space (fig. 33, *p. s.*) before hatching, and the embryo appears older than the escaped larvæ of many forms.

It is characterized, at the later stage examined (fig. 33), by the posterior position of the oil-globule (*o. g.*), and the great breadth and peculiar pigmentation of the marginal fins. The rectum (*r.*) lies close against the yolk, behind the oil-globule, and the imperforate anus (*a.*) is marginal. The eyes are very large, the mid-brain (*m. b.*) dorsally prominent, and the otocysts (*ot.*) are elongated and inferiorly concave. The dorsal marginal fin extends forward in front of the fore-brain, rising abruptly; just behind the anus the trunk has a height of ·27 mm., the ventral fin being ·40 mm., and the dorsal about equal in height to the body.

Greenish pigment (ochreish-yellow by transmitted light) occurs in small chromatophores over the yolk-sac, and sparingly on the greater part of the head and trunk, and along the dorsal and ventral fins about the middle of their width. There are a few large black stellate chromatophores, with the greenish pigment, about the oil-globule, and smaller rounded black chromatophores occur over the yolk-sac, and dorsally and ventrally about the anal region of the trunk. A series of peculiar pectinate black chromatophores run along the margin of the embryonic fin backwards from the anal region. I could not see any signs of the pectoral fins.

I have no suggestion to offer as to the parent form. It is noteworthy that these eggs, too conspicuous to escape detection, were only obtained in comparatively open waters.

NOTE ADDED IN PRESS.

Labrus maculatus (p. 449).—I had overlooked the late Mr. J. Duncan Matthews's description of the nest, ova, and larvæ of this species. The ova are about 1 mm. in diameter, and the newly-hatched larvæ are 3·75 mm. long; they are decorated with black and yellow pigment.—("Report Fishery Board, Scotland, 1887," pp. 245–247, pl. xi.)

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DEMERSAL OVA.
20 to 22.

Where there is Variation in the Ova of a species, the average dimensions are shown.

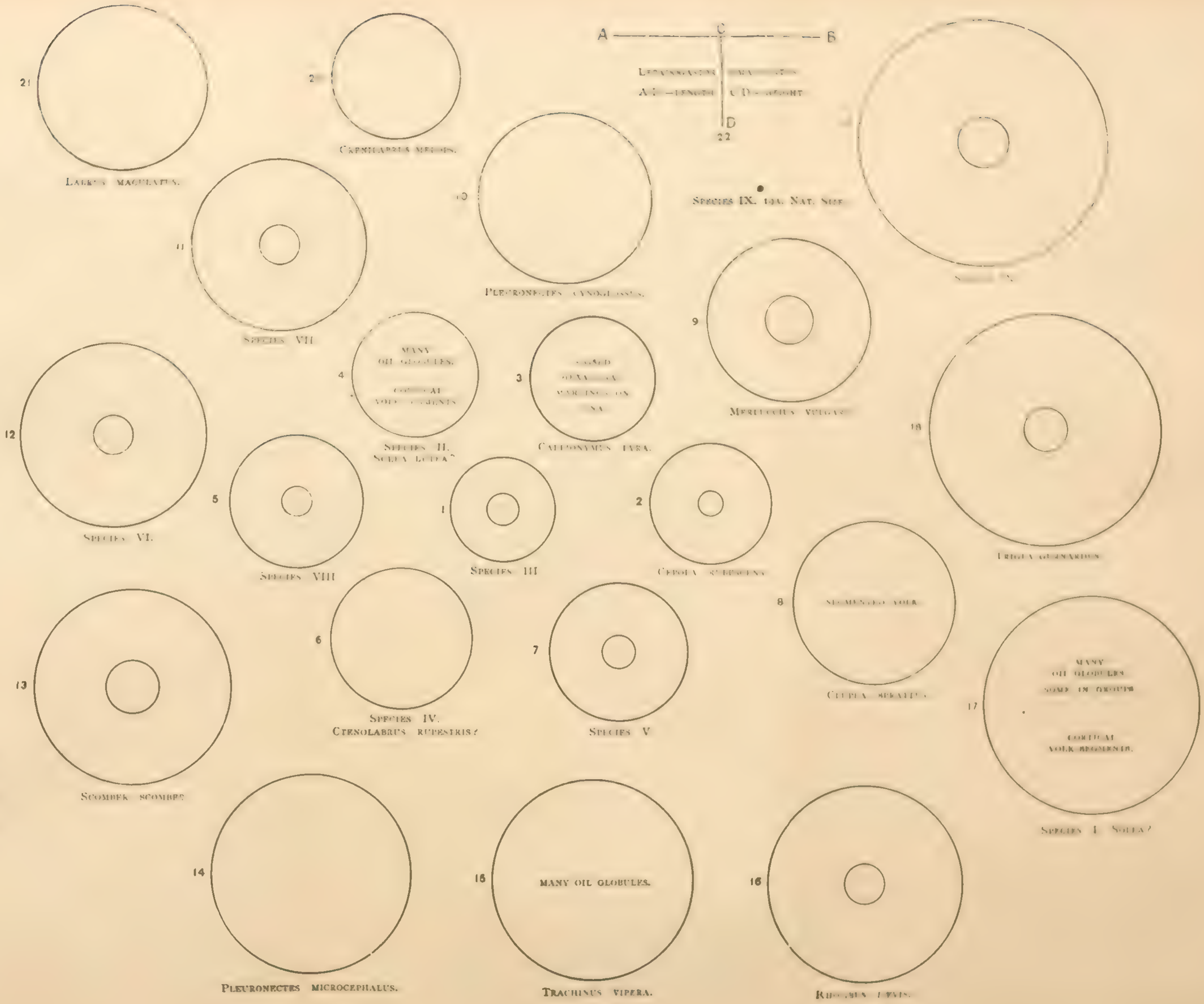


PLATE XLVII.

ON THE EGGS AND LARVÆ OF TELEOSTEANS.

LETTERING ADOPTED IN ALL THE FIGURES.

a.	anus.
a. b. . .	air-bladder.
b. . . .	blastoderm.
b. b. . .	branchial bar.
b. r. . .	blastodermic rim.
cl. . .	clavicle.
c. r. . .	epiblastic ridge connecting pectoral and pelvic fins.
c. v. . .	cortical vesicles or segments of yolk.
d. 1. . .	site of permanent first dorsal fin.
d. 2. . .	permanent second dorsal fin.
f. . . .	precephalic vesicular expansion of dorsal fin.
f. b. . .	fore-brain.
fil. . . .	filaments of attachment process.
g. b. . .	gall-bladder.
h. . . .	heart.
hm. . .	hyomandibular cartilage.
hp. . . .	hypural lobe of tail.
hy. . . .	hyoid arch.
k. v. . .	Kupffer's vesicle.
l. . . .	liver.
l. s. o. . .	lateral sense organ.
m. . . .	mouth.
m. b. . .	mid-brain.
mi. . . .	micropyle (closed).
m. o. . .	medulla oblongata.
no. . . .	notochord.
n. v. . .	nasal valve.
o. g. . .	oil-globule. *o. g.* 1. minute aggregated globules. *o. g.* 2. larger scattered globules.
ol. . . .	nasal sac.
op. . .	opercular flap.
ot. . . .	otocyst.
p. a. f. .	embryonic pre-anal fin.
p. b. . .	pigment bar.
p. f. . .	pectoral fin.
pl. f. . .	pelvic fin.
pn. . . .	pineal body.
p. s. . .	perivitelline space.
p. v. f. .	permanent ventral fin.
r. . . .	rectum.
rd. . . .	rod-like attachment-process of zona.
r. p. . .	rim of central pedicle of attachment.
r. v. . .	rectal valve.
s. . . .	dilatation of gut in region of future stomach.
st. . . .	stratified inner layer of egg-capsule.
u. . . .	urocyst,
v. m. . .	outer layer of egg-capsule: vitelline membrane of Brook.
y. . . .	yolk.
y. s. . .	yolk-sac.
z. r. . .	zona radiata.

EXPLANATION OF PLATE XLVII.

Figs. 1 to 12.

[*The pigment, except when otherwise specified, is shown as by reflected light.*]

Figure

1. Egg of *Lepadogaster bimaculatus*, from side.

2, 3. Eggs of the same, from above.

4. Pedicle of attachment, and part of inferior region of zona of the same, more highly magnified.

5. Yolk of newly-hatched larva of the same, from below.

6. Newly-hatched larva of the same, from the side.

7. The same as fig. 6, from above.

8. Optical section of egg-capsule of *Trachinus vipera*.

9. Egg of Species II. *Solea lutea*. (?)

10. Egg of the same, less advanced.

11. Egg of Species III.

12. Post-larval Goby, probably *Gobius niger* (by transmitted light).

Fig. 1.

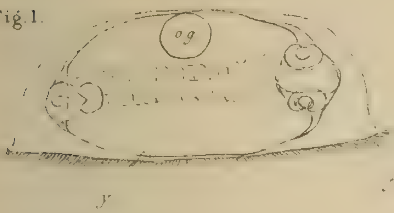


Fig. 2.

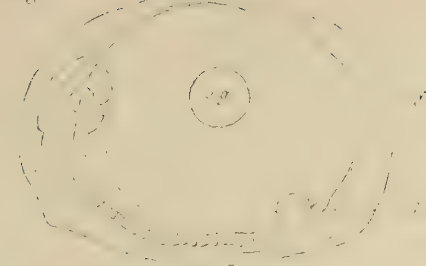


Fig. 3.

Fig. 4.

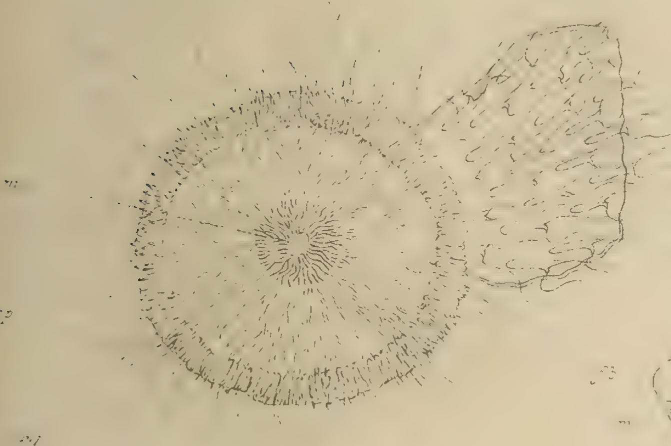


Fig. 7.

Fig. 6.

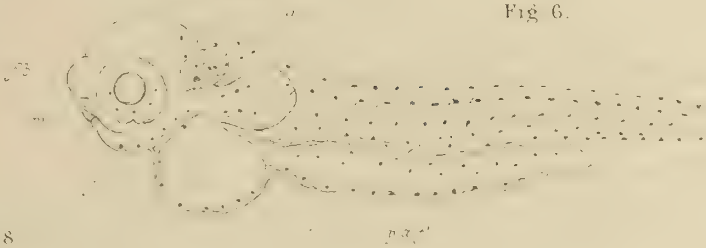


Fig. 8.

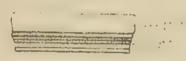


Fig. 9.

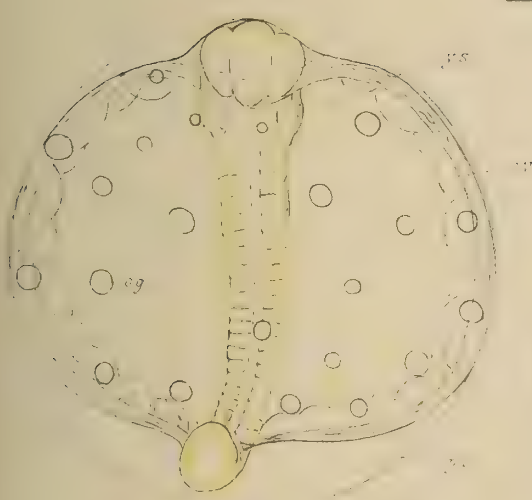


Fig. 5.

Fig. 10.

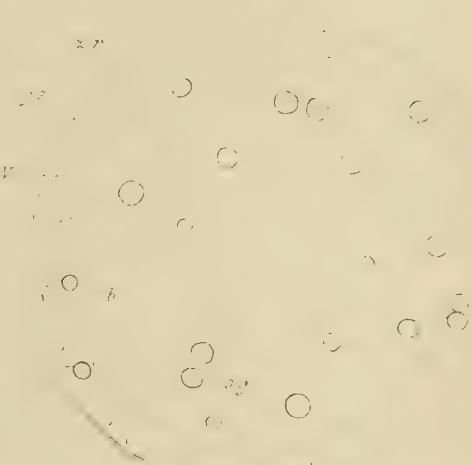
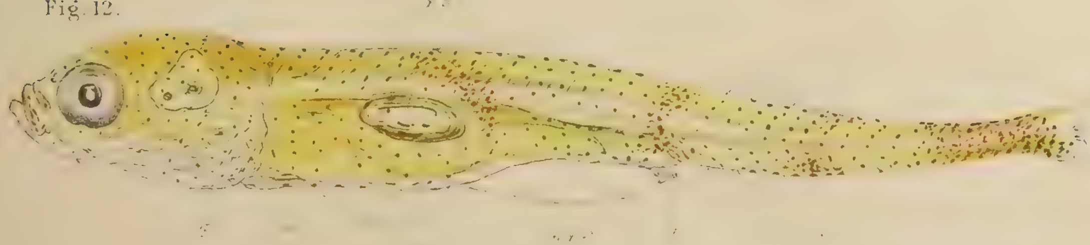


Fig. 11.

Fig. 12.



E. W. L. Holt del.

PLATE XLVIII.

ON THE EGGS AND LARVÆ OF TELEOSTEANS.

LETTERING ADOPTED IN ALL THE FIGURES.

a.	anus.
a. b. . .	air-bladder.
b. . . .	blastoderm.
b. b.. . .	branchial bar.
b. r. . .	blastodermic rim.
cl., . . .	clavicle.
c. r. . .	epiblastic ridge connecting pectoral and pelvic fins.
c. v. . .	cortical vesicles or segments of yolk.
d. 1. . .	site of permanent first dorsal fin.
d. 2. . .	permanent second dorsal fin.
f. . . .	precephalic vesicular expansion of dorsal fin.
f. b. . .	fore-brain.
fil. . . .	filaments of attachment process.
g. b. . .	gall-bladder.
h. . . .	heart.
hm. . .	hyomandibular cartilage.
hp. . . .	hypural lobe of tail.
hy. . . .	hyoid arch.
k. v. . .	Kupffer's vesicle.
l. . . .	liver.
l. s. o. . .	lateral sense organ.
m. . . .	mouth.
m. b. . .	mid-brain.
mi. . . .	micropyle (closed).
m. o. . .	medulla oblongata.
no. . . .	notochord.
n. v. . .	nasal valve.
o. g. . .	oil-globule. *o. g.* 1. minute aggregated globules. *o. g.* 2. larger scattered globules.
ol. . . .	nasal sac.
op. . . .	opercular flap.
ot. . . .	otocyst.
p. a. f. . .	embryonic pre-anal fin.
p. b. . .	pigment bar.
p. f. . .	pectoral fin.
pl. f. . .	pelvic fin.
pn. . . .	pineal body.
p. s. . .	perivitelline space.
p. v. f. . .	permanent ventral fin.
r. . . .	rectum.
rd. . . .	rod-like attachment-process of zona.
r. p. . .	rim of central pedicle of attachment.
r. v. . .	rectal valve.
s. . . .	dilatation of gut in region of future stomach.
st. . . .	stratified inner layer of egg-capsule.
u. . . .	urocyst.
v. m. . .	outer layer of egg-capsule: vitelline membrane of Brook.
y. . . .	yolk.
y. s. . .	yolk-sac.
z. r. . .	zona-radiata.

EXPLANATION OF PLATE XLVIII.

Figs. 13 to 24.

[*The pigment, except when otherwise specified, is shown as by reflected light.*]

Figure.

13. Ripe unfertilized egg of *Rhombus lævis.*
14. Fertilized egg of the same (?), advanced, from the tow-net.
15. Egg of *Trachinus vipera*, with embryo showing the paired fins (*p. f.* and *pl. f.*) connected by a continuous ridge (*c. r.*). Pigment and oil-globules omitted.
16. Egg of Species V., early stage.
17. Advanced egg of Species VI.
18. Egg of Species VII.
19. Egg of *Pleuronectes microcephalus*, with unpigmented embryo.
20. Part of zona of the same, flattened, Z. D. Oc. 2, Cam. luc.
21. The same, seen obliquely, in living egg.
22. Ripe unfertilized egg of *Cepola rubescens:* dead.
23. Egg of Species IV. *Ctenolabrus rupestris.* (?)
24. More advanced egg of the same, more highly magnified.

Fig. 13.

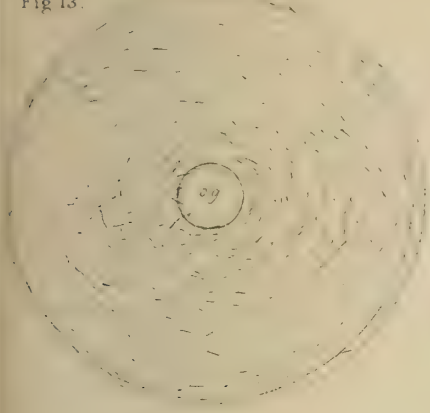


Fig. 15.

Fig. 14.

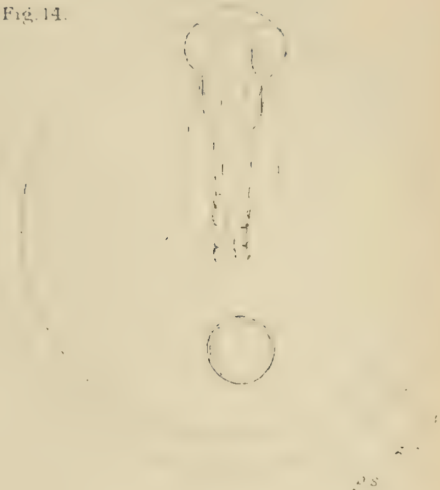


Fig. 16.

Fig. 17.

Fig. 18.

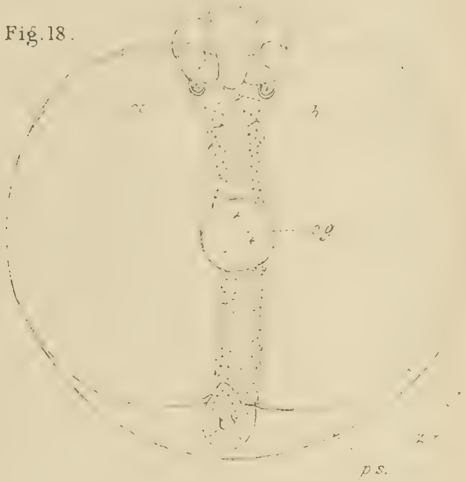


Fig. 19.

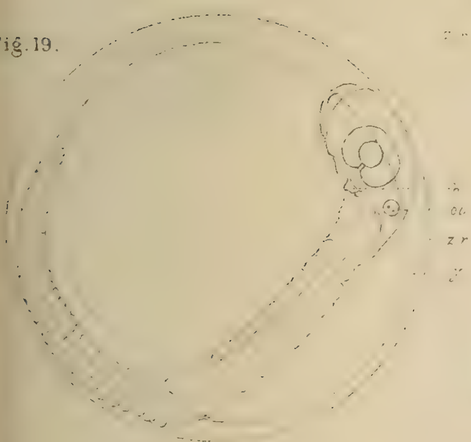


Fig. 20.

Fig. 21.

Fig. 22.

Fig. 23.

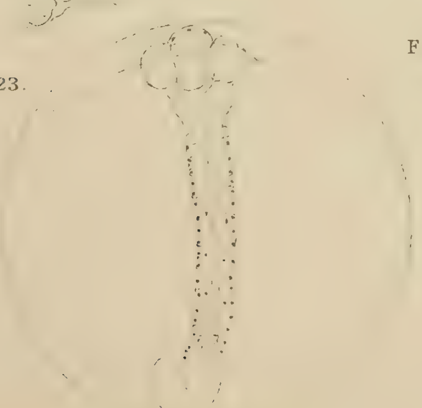
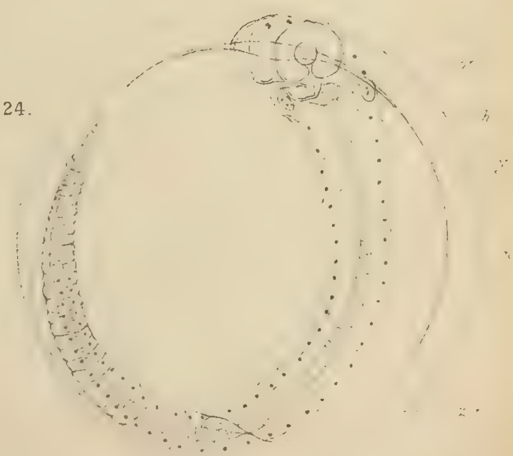


Fig. 24.



E. W. L. Holt, del.

PLATE XLIX.

ON THE EGGS AND LARVÆ OF TELEOSTEANS.

LETTERING ADOPTED IN ALL THE FIGURES.

a.	anus.
a. b.	air-bladder.
b.	blastoderm.
b. b.	branchial bar.
b. r.	blastodermic rim.
cl.	clavicle.
e. r.	epiblastic ridge connecting pectoral and pelvic fins.
e. v.	cortical vesicles or segments of yolk.
d. 1.	site of permanent first dorsal fin.
d. 2.	permanent second dorsal fin.
f.	precephalic vesicular expansion of dorsal fin.
f. b.	fore-brain.
fil.	filaments of attachment process.
g. b.	gall-bladder.
h.	heart.
hm.	hyomandibular cartilage.
hp.	hypural lobe of tail.
hy.	hyoid arch.
k. v.	Kupffer's vesicle.
l.	liver.
l. s. o.	lateral sense organ.
m.	mouth.
m. b.	mid-brain.
mi.	micropyle (closed).
m. o.	medulla oblongata.
no.	notochord.
n. v.	nasal valve.
o. g.	oil-globule. *o. g.* 1. minute aggregated globules. *o. g.* 2. larger scattered globules.
ol.	nasal sac.
op.	opercular flap.
ot.	otocyst.
p. a. f.	embryonic pre-anal fin.
p. b.	pigment bar.
p. f.	pectoral fin.
pl. f.	pelvic fin.
pn.	pineal body.
p. s.	perivitelline space.
p. v. f.	permanent ventral fin.
r.	rectum.
rd.	rod-like attachment-process of zona.
r. p.	rim of central pedicle of attachment.
r. v.	rectal valve.
s.	dilatation of gut in region of future stomach.
st.	stratified inner layer of egg-capsule.
u.	urocyst,
v. m.	outer layer of egg-capsule: vitelline membrane of Brook.
y.	yolk.
y. s.	yolk-sac.
z. r.	zona radiata.

EXPLANATION OF PLATE XLIX.

Figs. 25 to 33.

[*The pigment, except when otherwise specified, is shown as by reflected light.*]

Figure

25. Egg of Species VII., four days older than fig. 18, pl. II.

25*a*. Part of notochord of same, more highly magnified.

26. Egg of Species I. *Solea.* (?)

27. Egg of Species VIII.

28, 29. Larva of Species IV. *Ctenolabrus rupestris.* (?) Some time after hatching. Ventral and profile view.

30. Cephalic region of same, more highly magnified.

31. Egg of *Trachinus vipera*, early stage, × 40.

32. Advanced stage of same, more highly magnified.

33. Egg of Species IX. (by transmitted light).

Fig. 25.

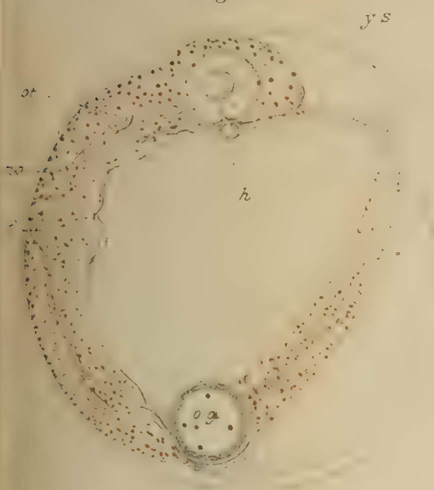


Fig. 31.

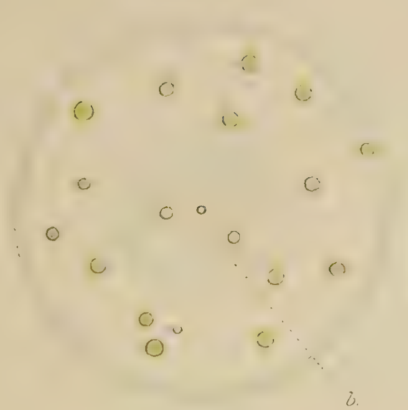


Fig. 26.

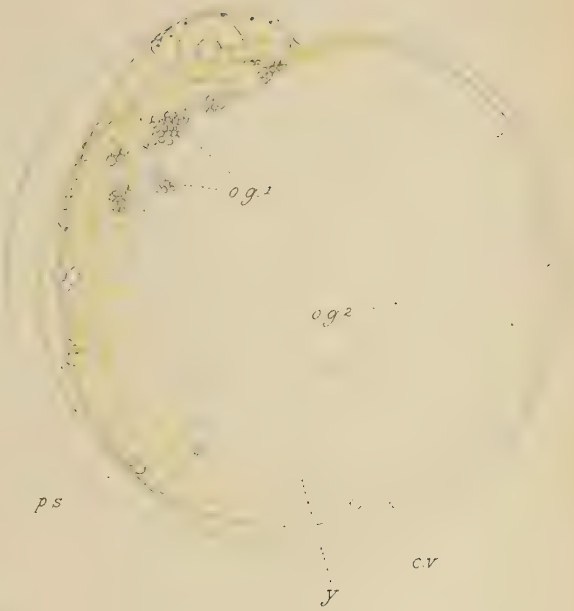


Fig. 25 a

Fig. 27.

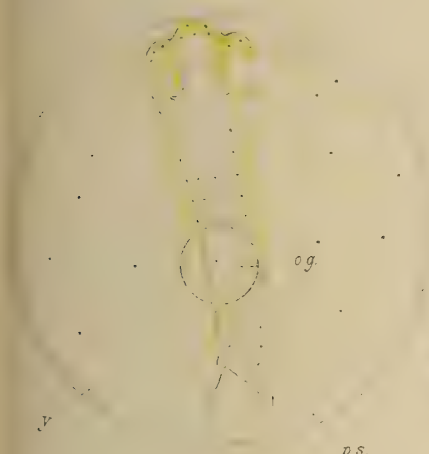


Fig. 28.

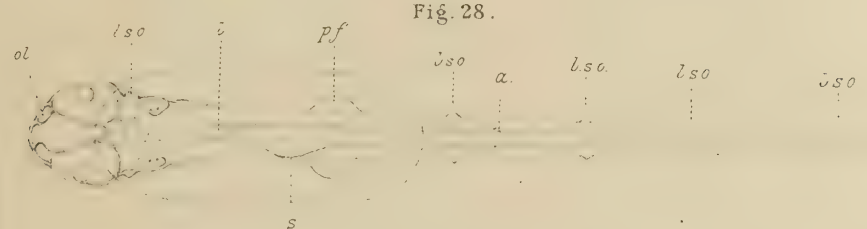


Fig. 29.

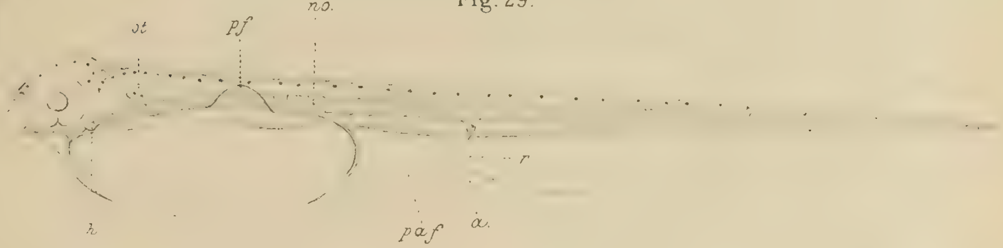


Fig. 32.

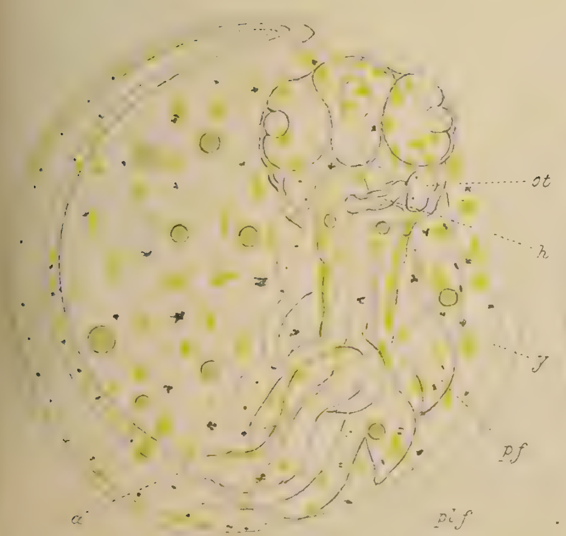


Fig. 30.

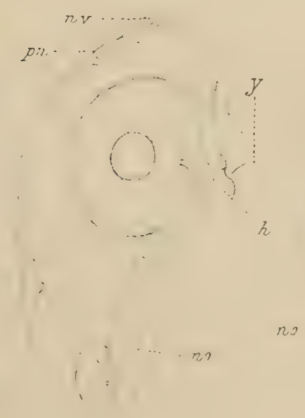


Fig. 33.

PLATE L.

ON THE EGGS AND LARVÆ OF TELEOSTEANS.

LETTERING ADOPTED IN ALL THE FIGURES.

a.	anus.
a. b.	air-bladder.
b.	blastoderm.
b. b.	branchial bar.
b. r.	blastodermic rim.
cl.,	clavicle.
c. r.	epiblastic ridge connecting pectoral and pelvic fins.
c. v.	cortical vesicles or segments of yolk.
d. 1.	site of permanent first dorsal fin.
d. 2.	permanent second dorsal fin.
f.	precephalic vesicular expansion of dorsal fin.
f. b.	fore-brain.
fil.	filaments of attachment process.
g. b.	gall-bladder.
h.	heart.
hm.	hyomandibular cartilage.
hp.	hypural lobe of tail.
hy.	hyoid arch.
k. v.	Kupffer's vesicle.
l.	liver.
l. s. o.	lateral sense organ.
m.	mouth.
m. b.	mid-brain.
mi.	micropyle (closed).
m. o.	medulla oblongata.
no.	notochord.
n. v.	nasal valve.
o. g.	oil-globule. *o. g.* 1. minute aggregated globules. *o. g.* 2. larger scattered globules.
ol.	nasal sac.
op.	opercular flap.
ot.	otocyst.
p. a. f.	embryonic pre-anal fin.
p. b.	pigment bar.
p. f.	pectoral fin.
pl. f.	pelvic fin.
pn.	pineal body.
p. s.	perivitelline space.
p. v. f.	permanent ventral fin.
r.	rectum.
rd.	rod-like attachment-process of zona.
r. p.	rim of central pedicle of attachment.
r. v.	rectal valve.
s.	dilatation of gut in region of future stomach.
st.	stratified inner layer of egg-capsule.
u.	urocyst.
v. m.	outer layer of egg-capsule: vitelline membrane of Brook.
y.	yolk.
y. s.	yolk-sac.
z. r.	zona-radiata.

EXPLANATION OF PLATE L.

Figs. 34 to 39.

[*The pigment, except when otherwise specified, is shown as by reflected light.*]

Figure.

34. Larva of Species I. *Solea.* (?) Profile view.
35. Dorsal view of anterior region of the same.
36. Larva of Species VIII., about twelve hours after hatching
37. Larva of *Trachinus vipera,* shortly after hatching.
38. The same, early post-larval stage.
39. Larva of *Pleuronectes microcephalus* (by transmitted light).

Fig. 38.

Fig. 37.

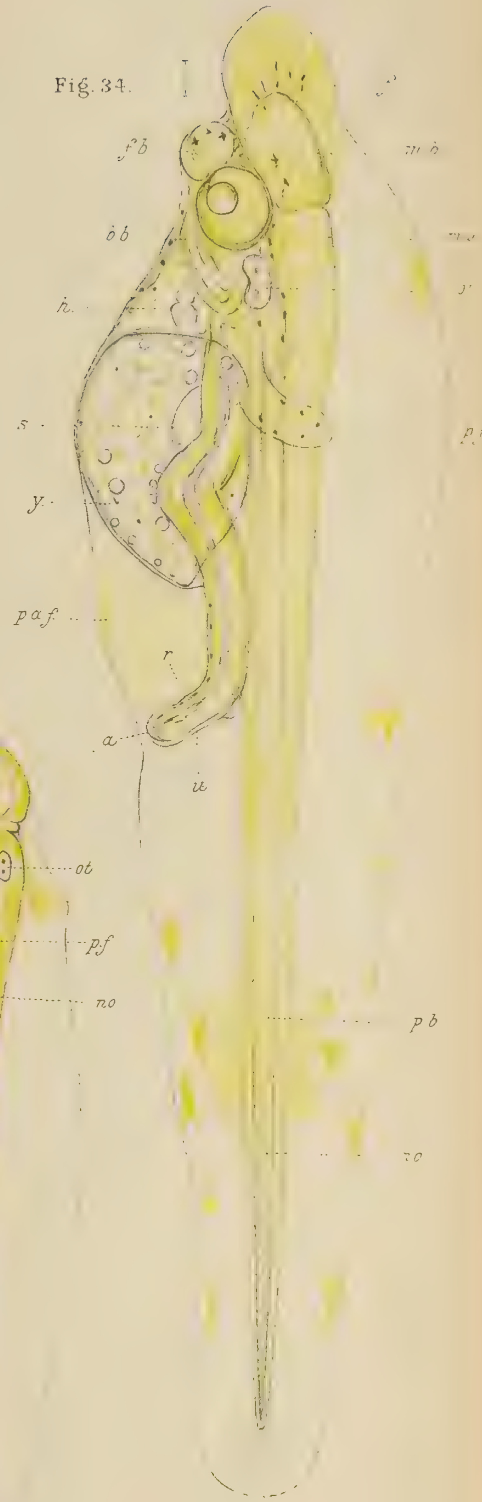


Fig. 34.

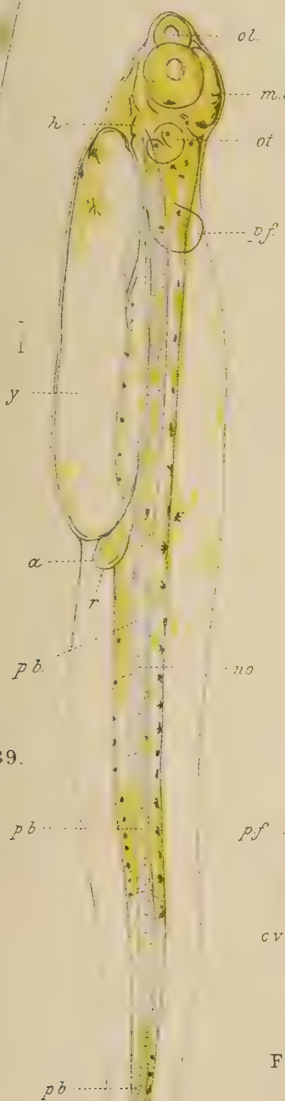


Fig. 39.

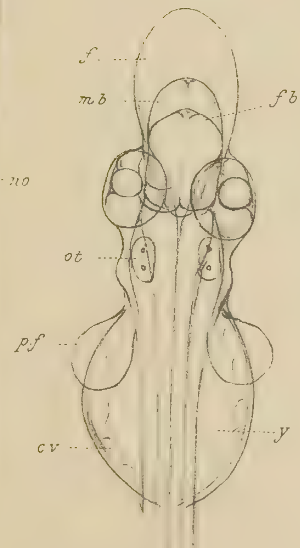


Fig. 35.

Fig. 36.

PLATE LI.

ON THE EGGS AND LARVÆ OF TELEOSTEANS.

LETTERING ADOPTED IN ALL THE FIGURES.

a.	anus.
a. b.	air-bladder.
b.	blastoderm.
b. b.	branchial bar.
b. r.	blastodermic rim.
cl.	clavicle.
c. r.	epiblastic ridge connecting pectoral and pelvic fins.
c. v.	cortical vesicles or segments of yolk.
d. 1.	site of permanent first dorsal fin.
d. 2.	permanent second dorsal fin.
f.	precephalic vesicular expansion of dorsal fin.
f. b.	fore-brain.
fil.	filaments of attachment process.
g. b.	gall-bladder.
h.	heart.
hm.	hyomandibular cartilage.
hp.	hypural lobe of tail.
hy.	hyoid arch.
k. v.	Kupffer's vesicle.
l.	liver.
l. s. o.	lateral sense organ.
m.	mouth.
m. b.	mid-brain.
mi.	micropyle (closed).
m. o.	medulla oblongata.
no.	notochord.
n. v.	nasal valve.
o. g.	oil-globule. *o. g.* 1. minute aggregated globules. *o. g.* 2. larger scattered globules.
ol.	nasal sac.
op.	opercular flap.
ot.	otocyst.
p. a. f.	embryonic pre-anal fin.
p. b.	pigment bar.
p. f.	pectoral fin.
pl. f.	pelvic fin.
pn.	pineal body.
p. s.	perivitelline space.
p. v. f.	permanent ventral fin.
r.	rectum.
rd.	rod-like attachment-process of zona.
r. p.	rim of central pedicle of attachment.
r. v.	rectal valve.
s.	dilatation of gut in region of future stomach.
st.	stratified inner layer of egg-capsule.
u.	urocyst,
v. m.	outer layer of egg-capsule: vitelline membrane of Brook.
y.	yolk.
y. s.	yolk-sac.
z. r.	zona radiata.

EXPLANATION OF PLATE LI.

Figs. 40 to 45.

[*The pigment, except when otherwise specified, is shown as by reflected light.*]

Figure

40, 41. Newly-hatched larva of *Callionymus lyra.* Ventral and profile views.

42. Larva of the same, about twelve hours old.

43. Larva of Species V., shortly after hatching.

44. The same larva, one day older.

45. Part of notochord of the same, more highly magnified.

Fig. 41.

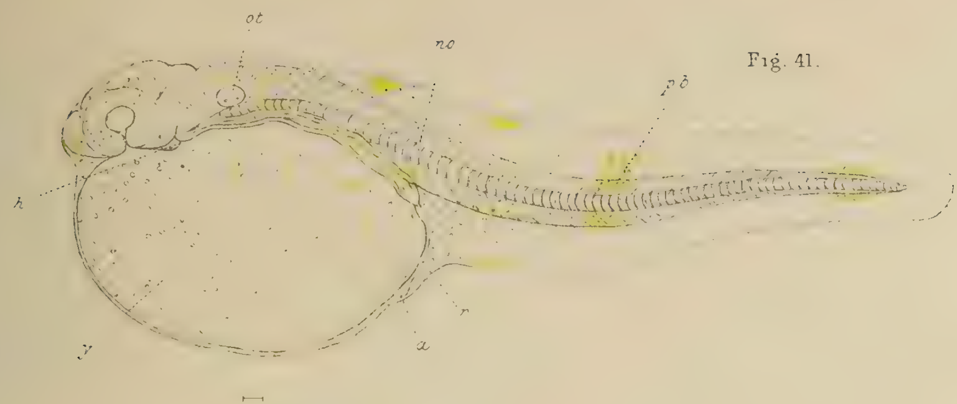


Fig. 42.

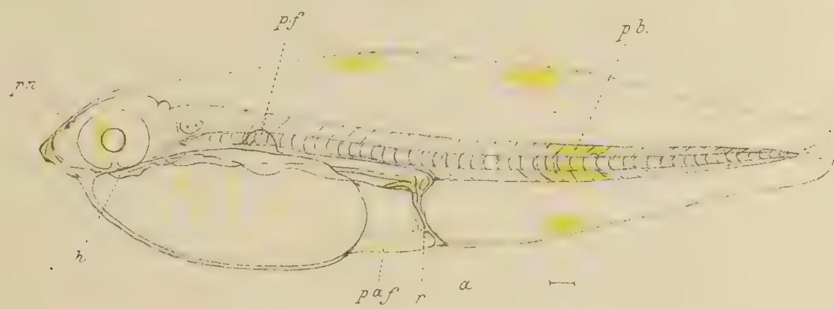


Fig. 40.

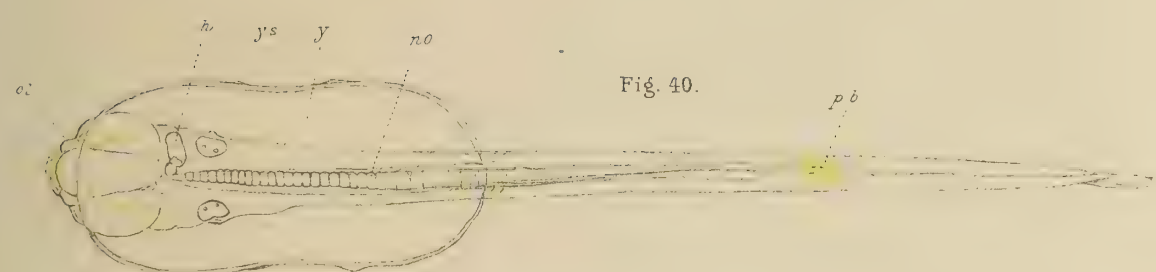


Fig. 43.

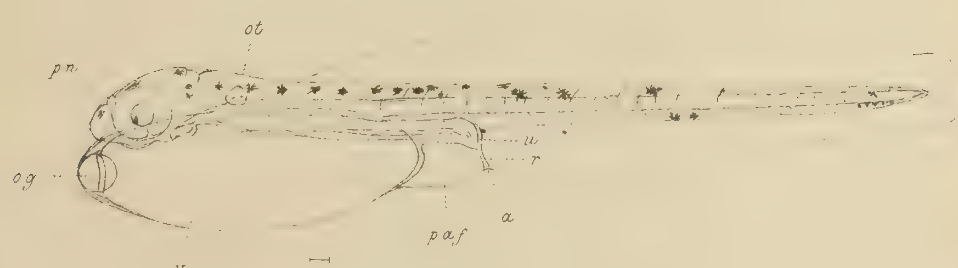


Fig. 44.

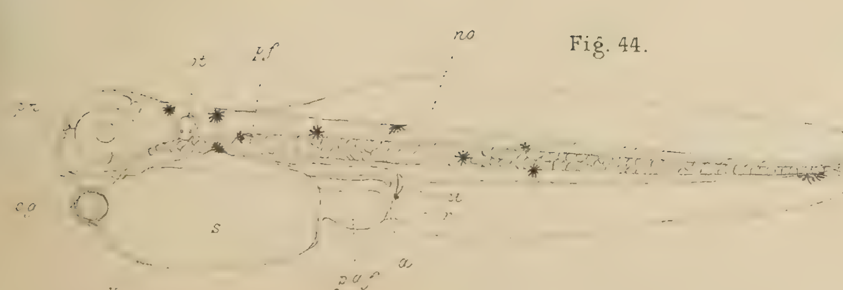


Fig. 45.

PLATE LII.

ON THE EGGS AND LARVÆ OF TELEOSTEANS.

LETTERING ADOPTED IN ALL THE FIGURES.

a.	anus.
a. b.	air-bladder.
b.	blastoderm.
b. b.	branchial bar.
b. r.	blastodermic rim.
cl.,	clavicle.
c. r.	epiblastic ridge connecting pectoral and pelvic fins.
c. v.	cortical vesicles or segments of yolk.
d. 1.	site of permanent first dorsal fin.
d. 2.	permanent second dorsal fin.
f.	precephalic vesicular expansion of dorsal fin.
f. b.	fore-brain.
fil.	filaments of attachment process.
g. b.	gall-bladder.
h.	heart.
hm.	hyomandibular cartilage.
hp.	hypural lobe of tail.
hy.	hyoid arch.
k. v.	Kupffer's vesicle.
l.	liver.
l. s. o.	lateral sense organ.
m.	mouth.
m. b.	mid-brain.
mi.	micropyle (closed).
m. o.	medulla oblongata.
no.	notochord.
n. v.	nasal valve.
o. g.	oil-globule. *o. g.* 1. minute aggregated globules. *o. g.* 2. larger scattered globules.
ol.	nasal sac.
op.	opercular flap.
ot.	otocyst.
p. a. f.	embryonic pre-anal fin.
p. b.	pigment bar.
p. f.	pectoral fin.
pl. f.	pelvic fin.
pn.	pineal body.
p. s.	perivitelline space.
p. v. f.	permanent ventral fin.
r.	rectum.
rd.	rod-like attachment-process of zona.
r. p.	rim of central pedicle of attachment.
r. v.	rectal valve.
s.	dilatation of gut in region of future stomach.
st.	stratified inner layer of egg-capsule.
u.	urocyst.
v. m.	outer layer of egg-capsule: vitelline membrane of Brook.
y.	yolk.
y. s.	yolk-sac.
z. r.	zona-radiata.

EXPLANATION OF PLATE LII.

Figs. 46 to 52.

[*The pigment, except when otherwise specified, is shown as by reflected light.*]

Figure.

46. Newly-hatched larva of Species II. *Solea lutea.* (?) Ventral view.
47. Larva of the same, about one day old. Profile view.
48. Larva of the same, two days old.
49. Larva of the same, four days old (by transmitted light).
50. Larva of the same, about six or seven days old (by transmitted light).
51. Anterior region of larva about six days old, more highly magnified.
52. Early post larval stage of the same, eight or nine days old.

Fig. 47.

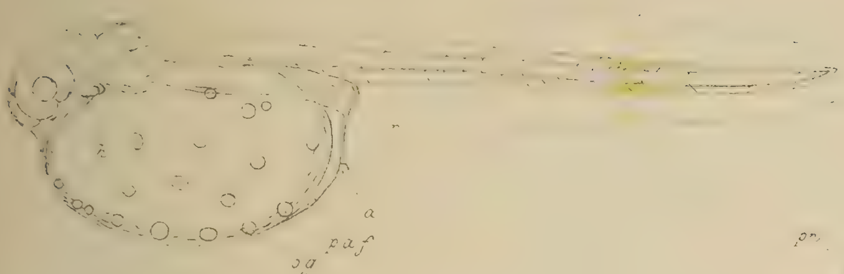


Fig. 51.

Fig. 48.

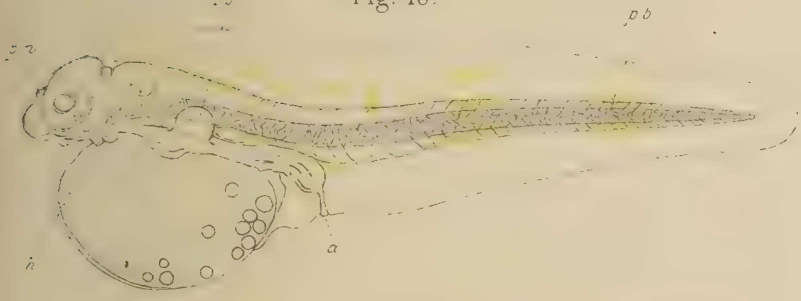


Fig. 49.

Fig. 46.

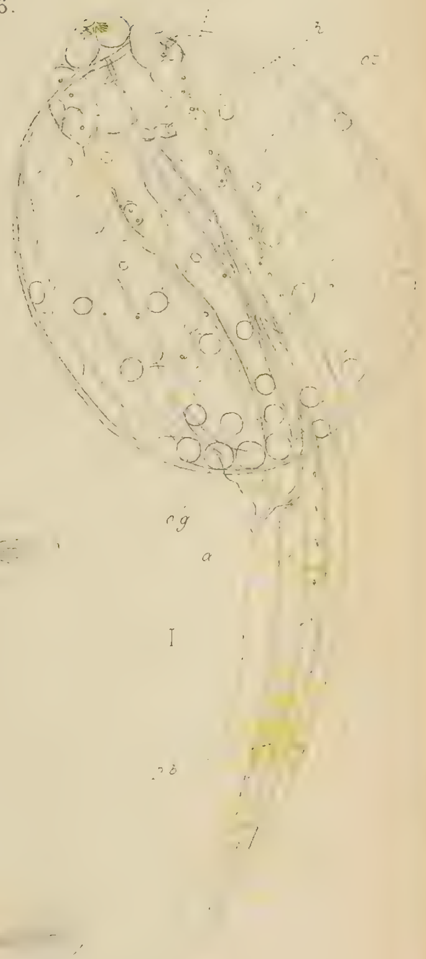


Fig. 50.

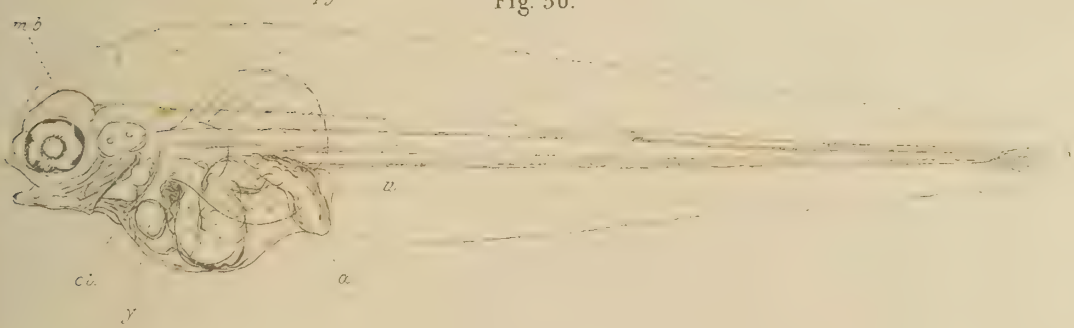


Fig. 52.

VIII.

THE CONSTRUCTION OF TELESCOPIC OBJECT-GLASSES FOR THE INTERNATIONAL PHOTOGRAPHIC SURVEY OF THE HEAVENS. By SIR HOWARD GRUBB, M.A.I., F.R.S., Hon. Sec. Royal Dublin Society.

[Read November 19, 1890.

In the construction of telescopic objectives for visual use, it is necessary to satisfy two conditions only, assuming, of course, that the quality of the material and the workmanship of the surfaces be perfect. These two conditions are, that the chromatic and spherical aberrations be corrected as nearly as possible. In the construction of objectives suitable for photography, it is necessary to satisfy a third condition, viz. freedom from coma in the lateral pencils, in order to obtain as perfect a field as possible.

If the lateral images of an ordinary telescopic objective be examined, it will be found that at a very small distance from the centre of the field of view, say 20′ or 30′, a very sensible coma is apparent: this coma is toward the axis, and gives the images the appearance shown in fig. 1. Owing to the small field usually employed, or necessary to be employed, in astronomical telescopes, this coma is rarely seen, but observers are quite familiar with the appearance of a star, when the objective is out of adjustment, and requires alteration to place its axis coincident with the axis of the tube. The appearance in that case is the same as that mentioned above, for the images that the observer then sees in the centre are really due to lateral pencils; and it is by the position of this coma that the observer determines the direction in which the necessary adjustment must be made, in order to utilize the central pencil, and get the best results.

Fig. 1.

In determining the best form to be given to these objectives, it was necessary to keep in view the ultimate purpose for which the photographs obtained by them were intended. Some forms of objectives give a very widely-spread coma, with a very distinct nucleus in the lateral images, and photographs taken with such objectives are sometimes very deceptive. For, if no large stars be upon

the plate, the images appear very perfect for a considerable distance from the centre, the fact being that the coma is so widely spread, and consequently weak in intensity, that it is invisible in the case of the smaller stars. On consideration, however, it will be seen that such images would be useless for the purpose required, viz. accurate measurements. The image of a small star would only be that of its nucleus, while the image of a large star would include the coma which extends in this case not symmetrically on each side of the nucleus, but almost altogether on the side toward the centre; consequently the distances of all large stars from a central point would measure too small, as compared with those of stars of less magnitude.

It is not possible to obtain absolutely round images of stars anywhere on a plate, except at or near the centre; but it is evidently necessary that whatever departure from a perfect circle the image may be, it must be symmetrical on each side of a tangential, as well as of a radial line cutting its centre (see fig. 2). That is to say, if C be the centre of the field, the image of the star must be symmetrical on both sides of the lines AB, CD. This, then, is the condition that must be satisfied in photographic objectives, as well as those mentioned before as necessary to be satisfied in the case of visual objectives, viz. freedom from chromatic and spherical aberrations.

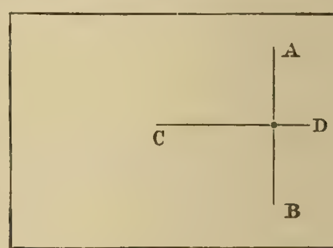


FIG. 2.

In addition to the conditions above mentioned which it is necessary should be satisfied in the case of all photographic objectives, one more condition insisted on in the case of the objectives for the International Survey was, that all objectives should be within a very small percentage of the same focal length.

A little consideration will show that the imposing of these two additional conditions increased in a very high degree the labour in the construction of the objectives. It is convenient in considering the various alterations in the form of objectives to imagine the glass flexible, and capable of being bent out of its normal state to any other required form. Taking the form of the ordinary visual objective to start with, which with the more usually used qualities of glass is


FIG. 3. FIG. 4. FIG. 5. FIG. 6.

almost a bi-convex crown with a plano-concave flint fitting as in fig. 3, it is necessary, in order to eliminate the coma, that the crown be either bent forwards on edge as in fig. 4, or the flint bent backwards as in fig. 5. In other words,

that the two lenses be of such a form as would touch in centre if placed close together. By continuing the bending a point is reached at which the coma is cured; if we go further we obtain coma outwards. When the proper balance of coma is obtained we have an objective of approximately the form shown in fig. 6.* But, unfortunately, whichever course we adopt, either that of bending forward the crown or bending backward the flint, the correction for spherical aberration is destroyed. Bending forward the crown renders it (the crown) a lens of greater positive spherical aberration, and bending back the flint renders it (the flint) a lens of less negative aberration. In either case the spherical aberration of the whole is rendered strongly positive.

Again, in order to correct the objective for coincidence of the active chemical rays, it is necessary either to increase the power of the crown, or reduce the power of the flint; and this again introduces more positive spherical aberration into the objective, the result being a lens, corrected for chemical rays, corrected for coma, but under-corrected by a considerable quantity for spherical aberration. In an ordinary visual objective if the spherical aberration be found to be under-corrected, a modification of the form of either of the components should be made in order to correct this, but in this case all four curves are already fixed in order to fulfil the three conditions of focal length, chromatic aberration, and spherical aberration, consequently there is no latitude for further alteration. The total power of the combination is already fixed in order to fulfil the condition of focal length. The proportion of the power of crown to flint is already a fixed quantity in order that the chemical rays be united. If therefore the total power of the combination, and the proportional power of crown to flint be fixed, the actual powers of crown and flint are also fixed quantities. Lastly, the proportion of power on each surface of crown and flint, *i. e.* the form of the lens, is either fixed, or variable only in such directions as will not sensibly alter the correction for spherical aberration of the whole combination, that is to say, the correction for coma may be made as before stated, either by bending forward the edge of the crown, or bending back the edge of the flint, or by a combination of both, but in any case the correction for spherical aberration is reduced.

As there is no possibility of altering the curves of *any* surface of the objective without destroying the correction for one or other of the foregoing, the only possibility of correcting the spherical aberration is by figuring the surfaces to a form other than that of a sphere, and this is the course I was obliged to adopt when using this particular form of objective.

* The same effect on coma can also be obtained by separating the crown and flint, but in most cases the amount of separation required is excessive, and introduces more positive spherical aberration than the other method.

During the course of my investigations on these objectives, I worked out another form which gives very admirable results, and without as much or indeed any sensible forcing of the curves out of the spherical form. This objective is shown in fig. 7. In this form the flint is the outermost, and receives the parallel rays; the two inside curves are, as in the other form, so proportioned that they would touch in the centre; and the outside of the crown is nearly plano. This lens when corrected for coincidence of the chemical rays and for coma, is very nearly correct for spherical aberration also, and therefore its preparation is less troublesome than the form first described. If the inside curves were made to coincide there would be coma, but its direction would be the reverse of that given by the first described form, viz. it would be from, instead of towards, the centre of the field of view. In the vicinity of smoky cities this form might be objected to. Having the flint glass exposed to the influence of the air, it is more likely to be injured than if the crown were outermost. This form corrected for visual rays would make an admirable objective for transit instruments, or in any case where a large field is required.

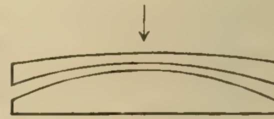


Fig. 7.

The testing and correcting of these photographic objectives is much more troublesome than that of visual objectives. In visual objectives, the judging as to the perfection of the chromatic and spherical aberrations is altogether a matter of experience of the eye of the observer. A very few moments of favourable observation on a star or small point of light is sufficient to enable the experienced eye to judge of the fault to be corrected in the case of visual objectives, but in the case of the photographic objective no visual observations are of any use whatever, except that the state of the chromatic aberration can be roughly estimated by observing through various coloured glasses, or better still, through a film of ammonio-oxide, or ammonio-nitrate of copper; but the amount of outstanding colour is so great that no judgment can be formed of the state of the spherical aberration, and for the final tests photographs must be taken at every step of the process. When it is remembered that a clear sky and the utmost perfection of driving mechanism in the most perfect order is necessary in order to obtain these photographs, it can easily be imagined how very great are the difficulties in the preparation of the object-glasses.

Every step in the final corrections and final adjustments require a photograph to be taken, and consequently some of the simpler adjustments which are generally made within the space of an hour or so in the case of visual objectives, require in the case of photographic objectives a series of photographs to be taken, sometimes in consequence of broken weather, extending over several days, or even weeks.

As I have mentioned before, the final and crucial test for these object-glasses

is that of its performance on celestial objects. Many trials and experiments were made to get satisfactory artificial stars for testing these glasses, but although these are amply sufficient and perfectly satisfactory for testing visual objectives, they have not been found of so much use in the testing of photographic objectives. They were used largely in the earlier process, and in case of bad weather were a considerable help in forwarding the work more quickly than could have been done were it necessary always to wait for fine nights. But for final tests nothing but the natural star was perfectly satisfactory. During the testing of seven of these objectives a considerable amount of experience in celestial photography has been obtained, and I take occasion to remark that my experience does not tally exactly with that of Dr. Gill respecting the influence of atmospheric disturbance on the photographed images of the stars. He has stated that, with an exposure of over five minutes, as perfect, or very nearly as perfect, star-plates can be obtained on nights when the atmosphere is highly disturbed as on those when the air is perfectly steady. My experience goes to corroborate this so far as the large stars are concerned, but not as respects the small stars, and I think this is easily explained. Bright stars with long exposures imprint images on the photographic plate of considerable diameter. It is not necessary to discuss whether this increase of diameter is due to some form of halation, or chemical action; the fact remains that the longer the exposure the larger the image printed on the plate by any star. Consequently it is easy to understand that atmospheric disturbance which causes, as all observers know, a flickering and wavering, and general unsteadiness of the image, will have little or no effect on the photographic image in the brighter stars, because the amount of that wavering will always be far less than, and well contained within, the area of the surface which these brighter stars occupy on the plate; but, in the case of small stars, and more particularly with very small stars, it is impossible to conceive that a point of light which would under favourable circumstances imprint itself as a speck of not more than $\frac{1}{200}$th to perhaps $\frac{1}{400}$th of an inch in diameter would produce equally perfect impressions on the plate if, during exposure, it wavered about over an area considerably more than its own diameter, and this is, as all observers know, the case on nights of bad definition. I was certainly surprised to find the very excellent images that were obtained of the larger and even moderate-sized stars on nights of exceedingly bad definition, but my experience shows that the images of smaller stars suffer very decidedly from the effect of atmospheric disturbance.

It may be interesting to record here that trials of a form of objective suitable for use either for a visual or a photographic purpose, proposed by Sir George G. Stokes have proved satisfactory. By separating the lenses of an ordinary visual objective, such as fig. 3, a point will be reached when the necessary correction for photographic rays will be obtained, but the spherical aberrations will then be

strongly positive. Sir George Stokes' suggestion is to grind the crown rather more convex on the inside than the outside, leaving the power of both crown and flint as before. The result of this will be to introduce a little positive spherical aberration. Let that be corrected by figuring the lens. When required for photographic use the lenses are separated as far as necessary to correct for photographic rays, and the crown lens is then reversed. The crown is now in a position of lower (positive) spherical aberration, and this balances the amount of aberration introduced by the separation. This has been successfully tried with small-sized objectives.

IX.

LUNAR RADIANT HEAT, MEASURED AT BIRR CASTLE OBSERVATORY, DURING THE TOTAL ECLIPSE OF JANUARY 28, 1888. By OTTO BOEDDICKER, Ph. D. With an Introduction by THE EARL OF ROSSE, K.P., LL.D., F.R.S., &c., President of the Royal Dublin Society. Plates LIII., LIV., LV.

[Read February 18, 1891.]

Introduction.

Some years ago it was suggested that it would be desirable to turn the large Reflectors at Parsonstown, armed with the thermopile, upon the moon, with the view of detecting, and, if possible, measuring its radiant heat. Several attempts to do so had been made elsewhere, but without encouraging results. Melloni had employed a lens of three feet aperture of imperfect quality, but sufficiently good for the purpose. Owing, however, to the large absorption of heat by glass he obtained no very certain indications, his pile could not have received any of the less refrangible heat rays through the glass, but it appeared quite possible that with a speculum of equal aperture far more decided and really interesting and instructive results might be arrived at. Accordingly, I procured a thermopile of four elements, with surface of face half an inch square, from Messrs. Elliott, fixed it in the principal focus of a concave reflector of three and a-half inches aperture and three inches focus, and placed the whole in my three-foot telescope, the concave mirror being situated at the focus, and directed towards the speculum. Thus the whole of the Moon's radiant heat (and light) which entered the three-foot tube was concentrated upon a spot of one-third of an inch in diameter, on the centre of the face of the pile. At first the indications were very uncertain. They were so masked by accidental disturbances that they could be detected with certainty only by taking the mean of a series of readings with the telescope directed towards the Moon, and comparing it with that of a series with the telescope turned away from the Moon. I then procured a second pile from Messrs. Elliott, fitted it and a similar concave reflector close beside the first, and placed both piles, but with poles in reversed position, in the same circuit with the galvanometer. Thus, by turning the telescope, so that the Moon's image fell

alternately upon each pile, the effect sought for was nearly doubled, while extraneous disturbing effects tended generally to counteract one another. Still the needle was at all times more or less, and often very unsteady, though by taking means of a long series of alternate readings it was found possible, not only to demonstrate the existence of a very appreciable amount of radiation, but even roughly to estimate its variation with the phase and form, a curve generally representing that variation. The results were published in the *Proceedings* of the Royal Society, No. 112, 1869.

During the following season the experiments were pursued with modified apparatus; and, under the idea that the annoying disturbances of the needle still subsisting were largely due to an inequality of power between the two piles, these were replaced by thermocouples of home manufacture, selected out of a number, so as to be as nearly alike as possible.* They are described in the *Proceedings* of the Royal Society, No. 122, 1870; the results were published in the *Proceedings*, No. 123, 1870. In addition to another heat-curve, which, notwithstanding the modifications of the piles, does not give a more precise determination, I was able by the interposition of a sheet of glass to show in the above communication that the Moon's heat differed materially from the Sun's in that it contained a much larger proportion of rays of low refrangibility. From the very rapid diminution of the heat towards New Moon it was probable that at that phase the remaining heat would be scarcely if at all appreciable, and from these two facts I concluded that the heat which I had been attempting to measure was heat received by the Moon from the Sun, but only re-radiated after part of it had been absorbed by the lunar surface, and then emitted as dark rays of heat. At the same time, so far as could be gathered from these rough determinations the maximum of heat did not take place as might, perhaps, have been expected to an appreciable degree after the maximum of light, that is after Full Moon. Some rough determinations of the proportion between lunar and solar radiation were also made.

At this stage Dr. Copeland, who had taken up the post of Astronomical Assistant in my Observatory, began to devote much labour and patience to the investigation, using the same apparatus, only refitted and adjusted, as I had employed in the season 1869–70. He formed a more concordant series of mean results, and having fully reduced them, and having by long series of observations at largely varying altitudes obtained a curve for the absorption of heat by our atmosphere, he was able to produce a more reliable phase-curve for heat.

The determinations of the quality of the radiation by interposition of a sheet

* The thermopiles of bismuth, and an alloy of 12 bismuth to 1 tin were replaced about three and a-half years ago by thermopiles of iron and German silver, the wire of commerce being used in each case.

of glass were repeated, and they confirmed, as far as possible, the former results. The phase-curve strengthened the previous impression that no appreciable interval existed between the time of maximum of light and of the maximum of heat; on the contrary, from some unexplained cause the maximum of heat seemed to occur somewhat before Full Moon.

Dr. Copeland's determinations, together with his discussion of them, were published in the *Philosophical Transactions* for 1873.

The striking result having been arrived at that the maximum of heat did not lag behind Full Moon, it appeared desirable to proceed a step further, and as a more rigid test to try how far the minimum of heat, which presumably existed during the progress of a lunar eclipse coincided with, or came later than the middle of that eclipse. Every visible lunar eclipse was eagerly waited for. The first occasion on which we were able to obtain a glimpse of the Moon during an eclipse was on November 14, 1872. The eclipse was only partial. The Moon was at a low and a diminishing altitude, and clouds interfered much. The heat radiation was, however, observed rapidly to decline during its progress, apparently as much as the light.

On October 4th, 1884, the next favourable opportunity occurred.* Dr. Boeddicker was on the spot with the apparatus in position from the commencement of the penumbra until forty minutes after the last contact with the penumbra. Clouds intervened until twenty-three minutes before totality, when the sky became perfectly clear, and remained so until the end of the observations. The heat as before diminished, and increased again nearly proportionally to the light, becoming inappreciable on reaching the limits of totality. The minimum of heat apparently fell later than that of illumination. But the most remarkable thing was that while during the short interval between the first contact with the penumbra and the commencement of total phase all appreciable radiation vanished, between the end of total phase and the last contact with the penumbra, and even forty minutes later the heat had not returned to the standard for Full Moon, being deficient by about twelve per cent. This we failed to explain, where we might expect to do so, by any derangement of the apparatus, nor could we trace it to any physical cause. The above observations were published in these *Transactions* for 1885 (vol. iii., series 2).

The next opportunity, an exceptionally favourable one, occurred on January 28, 1888. The sky was not obscured at all during the whole progress of the eclipse, and the same anomaly of the heat not returning to its standard value, even 1 hour 40 minutes after the last contact with the penumbra was observed. Also

* A total eclipse had meanwhile taken place on August 23, 1877, but owing to many interruptions from clouds, and the low altitude of the Moon, no advance was made. See *Copernicus*, vol. I., p. 22.

the radiation which we began to measure 1 hour 5 minutes before the first contact with the penumbra seemed to begin to decrease almost immediately; and even if the first observation be excluded, yet the decrease of heat seemed to begin as early as 15 minutes before the commencement of the eclipse. These results would appear to be particularly interesting as suggesting a terrestrial atmosphere much more extensive than it has generally been supposed to be which intercepts the Sun's rays of heat long before any part of the Moon has reached the Earth's shadow. We would much desire another opportunity for attacking the subject. As, however, it is exceedingly unlikely that the possibility of measuring the heat during an eclipse under similarly favourable meteorological conditions will soon recur here, and as it does not seem profitable to spend more time in getting a slightly more accurate phase-curve, it seems desirable that the present communication should close the series. If we pursue the subject of radiant heat further, it will be by making a new departure with apparatus modified so as if possible to combine greater sensibility with greater freedom from extraneous influences, varying also the methods, and extending the subjects and objects of investigation.

Dr. Boeddicker has devoted a great amount of time and labour to the fullest reductions, and to the formation of the theoretical curve for the Moon's light, possibly more than was justified by the probable errors of the observations, but as the occasion was quite an exceptional one it appeared best to leave nothing undone to get the utmost out of the night's work.

Lunar Radiant Heat.

I.—*The Observations of* 1888 *and their Reduction.*

1. As mentioned by Lord Rosse in his introduction to this Paper, my observations in 1884—the first really successful series of heat-observations during an eclipse—showed the striking anomaly, that 38 minutes after the last contact with the penumbra, the lunar heat still fell short of the Full Moon value by 13·2 %. Though I never doubted the reality of this very unexpected result, yet others did so; and the fact that the value for the lunar heat corresponding to Full Moon could not be obtained on the same night before the beginning of the eclipse (the Moon rose eclipsed, and clouds intervened till 23 minutes before the beginning of the total phase), but had to be deduced from extra-eclipse observations, gave a certain strength to these doubts. For it is well known how the state of the atmosphere affects these observations, and renders conclusions from one night to another difficult and uncertain. It became, therefore, most desirable to carry these observations on during an eclipse which could be watched at Birr Castle

Observatory during the whole of its course. Such an opportunity occurred on the 28th January, 1888, and was again exceptionally favoured by the weather, the sky being perfectly clear (without any wind) the whole night through.

2. The mode of observing was essentially the same as in 1884. The thermopiles of 1888, however—single thermic junctions—had been newly made by Lord Rosse for the occasion, and were very considerably more sensitive than the former ones. Consequently, one important alteration could be made, namely, each pile was exposed for 30 seconds sidereal time only (against one minute in 1884); or, in other words, the galvanometer was read off every half minute, as this time sufficed to obtain the maximum deflection. The labour of observing was divided in such a way that Lord Rosse watched the thermopiles, and the driving clock of the telescope, while I took all the readings of the galvanometer. The alternate exposing of the thermopiles, which is readily done by simply raising and lowering the telescope (of three-feet aperture) was done by an assistant, the signal for it being given by me every 30 seconds by means of an electric bell. The reading off of the galvanometer was carried on as far as possible continuously during the whole of the eclipse. Some interruptions could, however, not be avoided, and may be here at once enumerated.

3. Preliminary observations were taken from $3^h\ 20{\cdot}2^m$ to $3^h\ 25{\cdot}2^m$, and from $4^h\ 6{\cdot}7^m$ to $4^h\ 11{\cdot}7^m$ sidereal time. The continuous series commenced at $4^h\ 16{\cdot}7^m$. No observations were obtained from :—$4^h\ 37{\cdot}2^m$ to $4^h\ 39{\cdot}2^m$ (the zero point of the galvanometer had to be changed); $5^h\ 6{\cdot}2^m$ to $7{\cdot}7^m$ (three readings were missed, the signal not being understood by the assistant at the telescope); $5^h\ 14{\cdot}2^m$ to $20{\cdot}2^m$ (the clock-sector had to be wound back); $5^h\ 38{\cdot}2^m$ to $38{\cdot}7^m$ (one reading was missed); $5^h\ 48{\cdot}7^m$ to $6^h\ 0{\cdot}2^m$; $6^h\ 15{\cdot}7^m$ to $22{\cdot}7^m$; $6^h\ 25{\cdot}7^m$ to $45{\cdot}7^m$ (the driving-clock stopped through the slipping off of a band). From $6^h\ 45{\cdot}7^m$ till $8^h\ 23{\cdot}2^m$, which period embraces the time from $16{\cdot}3^m$ after the beginning, till $15{\cdot}6^m$ after the end of totality, a number of galvanometer readings were taken. Since, however, it became practically impossible to make sure of the lunar image being concentrated on the thermopiles (owing to the extreme faintness of the eclipsed moon), these observations, though given further on, could not be utilized for the construction of the final heat-curve. Observations began again at $8^h\ 28{\cdot}2^m$, and lasted till $11^h\ 52{\cdot}7^m$, with the following interruptions:—$9^h\ 18{\cdot}2^m$ to $23{\cdot}2^m$ (the clock-sector had to be wound back); $9^h\ 26{\cdot}7^m$ to $27{\cdot}7^m$ (one reading was missed); $9^h\ 50{\cdot}7^m$ to $52{\cdot}2^m$ (two readings were missed); $10^h\ 49{\cdot}2^m$ to $11^h\ 19{\cdot}2^m$ (observing was stopped for thirty minutes). It will be perceived from the above that observing was practically carried on from $7^h\ 19^m$ till $15^h\ 45^m$ mean time Greenwich, during which period I read off the galvanometer altogether 638 times.

4. As in 1884, the differences of the consecutive readings of the galvanometer were taken together in groups of ten, and the mean of each group was assumed to represent the heat-effect corresponding to the time of the sixth of the eleven readings which furnish the ten differences. Owing to the observations forming an all but uninterrupted series, this grouping was proceeded with from difference to difference, so that the epochs of the heat values vary generally speaking by $0{\cdot}5^m$ sidereal time only. Thus each reading was submitted to exactly the same treatment; and 473 values for the lunar heat were obtained. Of these 446 were available for the construction of the final heat curve. The first value, namely, corresponding to $3^h\ 22{\cdot}7^m$ (or $1^h\ 4{\cdot}2^m$ before the first contact with the penumbra) was excluded, as the Moon was still very low at that time, and situated, as seen from the Observatory, over the town of Parsonstown, so that but little reliance can be placed on it. And further, the values recorded during totality were excluded (as mentioned above) because the thermopiles were obviously not fully exposed to the lunar rays.

It may here be remarked that in the preliminary notes of these heat-observations which I communicated to *Nature* (No. 953, vol. xxxvii., February 2, 1888), and to the *Astronomische Nachrichten* (No. 2828, February 25, 1888) the observation of $3^h\ 22{\cdot}7^m$ was not excluded. The values given in the latter journal, being expressed in per cents. of the now excluded value, have, consequently, all to be corrected according to the present detailed publication.

5. The following Tables give the eclipse-observations in full. Their arrangement agrees strictly with Table I. in these *Transactions* for October, 1885, p. 323, containing the results of 1884. Any necessary explanations will be found on pp. 501 and 502.

TABLE I.

LUNAR HEAT DURING THE TOTAL ECLIPSE OF JANUARY 28, 1888.

I. Sidereal Time.	II. G.	III. $P. E.$	IV. z.	V. G_z.	VI. $\log \rho^2$.	VII. $\log R'^2$.	VIII. ϵ.	IX. Sid. Time from Middle of Eclipse.	X. G_z^*.	XI. G_z^* Curve.	XII. Curve minus Observ.	REMARKS.
h m			°				°	h m				
3 22·7	530·0	± 7·0	68·2	726·3	0·0013	0·0000	2·70	− 3 55·8	722·3	..	..	
4 9·2	535·5	13·1	61·6	652·5	·0010	..	·27	9·3	648·9	658·0	+ 9·1	
19·2	555·9	5·1	60·2	665·1	..	..	·16	2 59·3	661·6	655·8	− 5·8	
·7	554·6	6·1	·1	663·0	..	..	·16	58·8	659·5	655·3	− 4·2	
20·2	554·3	6·1	·0	662·1	..	..	·15	·3	658·8	654·1	− 4·7	
·7	555·3	5·8	·0	662·8	..	..	·15	57·8	659·4	653·6	− 5·8	
21·2	555·3	5·8	59·9	662·4	..	..	·15	·3	659·1	653·1	− 6·0	
·7	557·3	6·9	·8	664·2	..	..	·14	56·8	660·7	652·7	− 8·0	
22·2	558·0	7·0	·7	664·5	..	..	·14	·3	661·0	652·2	− 8·8	
·7	559·5	6·3	·7	665·9	..	..	·13	55·8	662·4	651·8	− 10·6	
23·2	557·2	8·1	·6	662·8	..	..	·13	·3	659·4	651·2	− 8·2	
·7	554·9	8·4	·5	659·4	..	..	·12	54·8	656·0	650·7	− 5·3	
24·2	554·2	8·2	·5	658·2	..	..	·12	·3	654·6	650·0	− 4·6	
·7	552·8	9·8	·4	655·7	..	..	·11	53·8	652·2	649·4	− 2·8	
25·2	550·2	11·4	·3	652·4	..	..	·11	·3	648·9	648·6	− 0·3	
·7	548·5	11·6	·2	649·8	..	..	·11	52·8	646·5	648·0	+ 1·5	
26·2	545·8	10·3	·2	646·2	..	..	·10	·3	642·7	647·2	+ 4·5	
·7	541·4	9·0	·1	640·3	..	..	·10	51·8	636·9	646·4	+ 9·5	
27·2	540·9	8·4	·0	639·3	..	..	·09	·3	636·0	645·7	+ 9·7	
·7	540·8	8·3	58·9	638·6	..	..	·09	50·8	635·3	645·0	+ 9·7	
28·2	542·8	8·7	·9	640·4	..	..	·08	·3	637·2	644·1	+ 6·9	
·7	546·1	10·8	·8	644·0	..	..	·08	49·8	640·7	643·2	+ 2·5	
29·2	547·1	11·4	·7	644·9	..	..	·08	·3	641·6	642·4	+ 0·8	
·7	550·1	10·3	·7	648·0	0·0010	..	·07	48·8	644·8	641·5	− 3·3	
30·2	554·4	8·9	·6	652·5	0·0009	..	·07	·3	649·2	640·6	− 8·6	
·7	556·4	8·1	·5	654·5	..	..	·07	47·8	651·0	639·8	− 11·2	
31·2	557·3	7·6	·5	655·1	..	..	·06	·3	651·6	638·8	− 12·8	
·7	549·4	22·6	·4	645·4	..	..	·06	46·8	641·9	637·8	− 4·1	
32·2	540·1	28·1	·3	634·0	..	..	·05	·3	630·6	636·9	+ 6·3	
·7	540·7	28·3	·2	634·3	..	..	·05	45·8	631·0	635·8	+ 4·8	
33·2	540·9	27·6	·2	634·0	..	..	·04	·3	630·6	634·6	+ 4·0	

I. Sidereal Time.	II. G.	III. $P. E.$	IV. z.	V. G_z.	VI. $\log \rho^2$.	VII. $\log R'^2$.	VIII. ϵ.	IX. Sid. Time from Middle of Eclipse.	X. G_z*.	XI. G_z* Curve.	XII. Curve minus Observ.	REMARKS.
h m			°				°	h m				
4 33·7	536·8	± 27·4	58·1	628·8	0·0009	0·0000	2·04	– 2 44·8	625·5	633·4	+ 7·9	
34·2	534·5	26·6	·0	625·6	..	..	·03	·3	622·3	632·4	+ 10·1	
·7	537·8	28·6	·0	629·1	..	..	·03	43·8	625·8	631·3	+ 5·5	
38·2	543·2	16·3	57·5	632·8	..	..	1·98	40·3	629·5	623·0	– 6·5	No observations from 4h 37·2m to 39·2m. 5 Differences before and 5 Differences after the interruption.
41·7	526·8	16·2	·0	611·2	..	..	·97	36·8	608·0	613·9	+ 5·9	
42·2	522·8	18·1	56·9	606·1	..	..	·95	·3	603·0	612·5	+ 9·5	
·7	518·3	19·4	·8	600·5	..	..	·95	35·8	597·3	611·2	+ 13·9	
43·2	521·5	16·2	·8	603·9	..	..	·94	·3	600·6	609·8	+ 9·2	
·7	526·4	20·7	·7	609·1	..	..	·94	34·8	605·9	608·3	+ 2·4	
44·2	525·9	20·7	·7	608·5	..	..	·93	·3	605·3	607·0	+ 1·7	
·7	525·5	20·5	·6	607·4	..	..	·93	33·8	604·2	605·6	+ 1·4	
45·2	516·8	22·7	·5	597·0	0·0008	..	·93	·3	593·9	604·1	+ 10·2	
·7	509·1	24·2	·4	587·8	..	..	·92	32·8	584·6	602·6	+ 18·0	
46·2	517·1	25·7	·4	596·8	..	..	·92	·3	593·6	601·0	+ 7·4	
·7	518·9	25·6	·3	598·4	..	..	·92	31·8	595·3	599·6	+ 4·3	
47·2	519·7	25·1	·2	599·1	..	..	·91	·3	596·0	598·1	+ 2·1	
·7	524·1	24·2	·2	603·7	..	..	·91	30·8	600·5	596·4	– 4·1	
48·2	515·4	27·4	·1	593·3	..	..	·90	·3	590·2	594·9	+ 4·7	
·7	509·7	25·6	·0	586·5	..	..	·90	29·8	583·4	593·2	+ 9·8	
49·2	506·4	22·9	·0	582·5	..	..	·90	·3	579·4	591·7	+ 12·3	
·7	504·9	20·7	55·9	580·3	..	..	·88	28·8	577·3	590·0	+ 12·7	
50·2	513·9	27·6	·8	590·5	..	..	·88	·3	587·3	588·2	+ 0·9	
·7	522·1	20·2	·7	599·5	..	..	·88	27·8	596·4	586·3	– 10·1	
51·2	517·1	18·5	·7	593·4	..	..	·87	·3	590·3	584·6	– 5·7	
·7	519·0	19·1	·6	595·3	..	..	·87	26·8	592·1	582·7	– 9·4	
52·2	520·7	18·3	·5	596·9	..	..	·86	·3	593·7	580·7	– 13·0	
·7	518·2	18·3	·5	593·7	..	..	·86	25·8	590·6	578·4	– 12·2	
53·2	526·4	12·0	·4	602·9	..	..	·85	·3	599·8	576·1	– 23·7	
·7	526·4	12·0	·3	602·6	..	..	·85	24·8	599·5	574·0	– 25·5	
54·2	518·9	18·9	·3	593·7	..	..	·84	·3	590·7	571·7	– 19·0	
·7	514·1	26·0	·2	587·9	..	..	·84	23·8	584·9	569·1	– 15·8	
55·2	504·4	20·3	·1	576·2	..	..	·83	·3	573·3	566·9	– 6·4	
·7	502·4	18·9	·1	573·7	..	..	·83	22·8	570·9	564·2	– 6·7	
56·2	501·0	18·9	·0	571·9	..	..	·83	·3	569·0	561·5	– 7·5	
·7	493·1	18·0	54·9	562·6	..	..	·82	21·8	559·8	559·0	– 0·8	

I. Sidereal Time.	II. G.	III. $P. E.$	IV. z.	V. G_z.	VI. log ρ^2.	VII. log R'^2.	VIII. ϵ.	IX. Sid. Time from Middle of Eclipse.	X. G_z*.	XI. G_z* Curve.	XII. Curve minus Observ.	REMARKS.
h m			°				°	h m				
4 57·2	487·2	± 19·5	54·8	555·5	0·0008	0·0000	1·82	−2 21·3	552·7	556·2	+ 3·5	
·7	480·4	20·7	·8	547·5	..	..	·81	20·8	544·8	553·8	+ 9·0	
58·2	478·3	18·7	·7	544·9	..	..	·80	·3	542·1	550·9	+ 8·8	
·7	476·7	16·8	·7	542·6	..	..	·80	19·8	539·9	548·2	+ 8·3	
59·2	475·4	19·0	·6	541·1	..	..	·79	·3	538·3	545·6	+ 7·3	
·7	469·8	21·9	·5	534·3	..	..	·79	18·8	531·6	542·8	+ 11·2	
5 0·2	468·8	22·1	·5	532·8	0·0007	..	·78	·3	530·2	539·9	+ 9·7	
·7	467·4	21·3	·4	531·1	..	..	·78	17·8	528·4	537·0	+ 8·6	
1·2	463·2	20·0	·3	526·1	..	..	·78	·3	523·5	534·1	+ 10·6	
·7	463·3	20·0	·3	525·9	..	..	·77	16·8	523·2	531·2	+ 8·0	
2·2	466·1	20·0	·2	528·8	..	..	·77	·3	526·1	528·3	+ 2·2	
·7	469·0	19·1	·1	531·8	..	..	·76	15·8	529·0	525·7	− 3·3	
3·2	465·8	16·2	·0	527·8	..	..	·76	·3	525·2	522·7	− 2·5	
·7	463·8	15·7	·0	525·3	..	..	·75	14·8	522·6	519·9	− 2·7	
7·0	440·1	27·3	53·5	496·9	..	..	·70	11·5	494·4	500·2	+ 5·8	No observations from 5h 6·2m to 7·7m. 5 Differences before and 5 Differences after the interruption.
10·2	427·1	20·9	·1	480·7	..	..	·69	8·3	478·3	478·9	+ 0·6	
·7	428·9	22·2	·1	482·5	..	..	·68	7·8	479·9	475·4	− 4·5	
11·2	429·1	22·2	·0	482·6	..	..	·68	·3	480·1	471·9	− 8·2	
·7	431·2	21·7	52·9	484·8	..	..	·68	6·8	482·2	468·1	− 14·1	
17·2	389·3	39·2	·2	435·2	0·0006	..	·63	1·3	433·0	423·5	− 9·5	No observations from 5h 14·2m till 20·2m. 5 Differences before and 5 after the interruption.
22·7	322·0	15·7	51·5	358·3	..	..	·58	1 55·8	356·6	370·9	+ 14·3	
23·2	320·2	15·2	·4	356·0	..	..	·58	·3	354·3	366·0	+ 11·7	
·7	317·2	16·5	·3	352·6	..	..	·57	54·8	351·0	361·1	+ 10·1	
24·2	316·1	15·9	·3	351·2	..	..	·57	·3	349·4	356·3	+ 6·9	
·7	311·8	16·2	·2	346·2	..	..	·56	53·8	344·5	351·1	+ 6·6	
25·2	312·0	14·4	·1	346·3	..	..	·56	·3	344·6	346·3	+ 1·7	
·7	313·2	13·5	·1	347·4	..	..	·55	52·8	345·7	341·2	− 4·5	
26·2	311·4	14·0	·0	345·3	..	..	·55	·3	343·8	336·7	− 7·1	
·7	306·0	15·9	·0	339·1	..	..	·54	51·8	337·5	332·0	− 5·5	
27·2	303·5	18·1	50·9	336·2	..	..	·53	·3	334·7	327·1	− 7·6	
·7	294·7	13·8	·8	326·3	..	..	·53	50·8	324·8	322·1	− 2·7	
28·2	290·4	14·4	·8	321·5	..	..	·53	·3	320·1	317·5	− 2·6	
·7	289·8	14·5	·7	319·6	..	..	1·53	49·8	318·2	312·6	− 5·6	
29·2	283·9	11·7	·6	314·1	..	..	..	·3	314·5	308·0	− 6·5	
·7	279·1	12·0	·6	308·6	..	..	..	48·8	309·0	303·1	− 5·9	

I. Sidereal Time.	II. G.	III. $P. E.$	IV. z.	V G_z.	VI. $\log \rho^2$.	VII. $\log R'^2$.	VIII. ϵ.	IX. Sid. Time from Middle of Eclipse.	X. G_z*.	XI. G_z* Curve.	XII. Curve minus Observ.	REMARKS.
h m			°				°	h m				
5 30·2	271·5	± 10·9	50·5	300·0	0·0005	0·0000	..	1 48·3	300·4	298·5	− 1·9	
·7	263·8	14·2	·4	291·4	..	..	..	47·8	291·7	293·7	+ 2·0	
31·2	256·9	14·2	·4	283·6	..	..	..	·3	283·9	289·1	+ 5·2	
·7	256·2	14·0	·3	282·7	..	..	..	46·8	283·0	284·3	+ 1·3	
32·2	254·1	14·4	·2	280·3	..	..	..	·3	280·6	279·9	− 0·7	
·7	250·4	14·9	·2	276·1	..	..	..	45·8	276·4	275·0	− 1·4	
33·2	245·7	13·9	·1	270·8	..	..	..	·3	271·1	270·8	− 0·3	
·7	239·3	11·9	·0	263·6	..	..	..	44·8	263·9	265·9	+ 2·0	
34·2	232·7	11·4	·0	256·3	..	..	..	·3	256·5	261·6	+ 5·1	
·7	228·0	10·9	49·9	250·9	..	..	..	43·8	251·3	257·0	+ 5·7	
35·2	223·3	12·4	·8	245·8	..	..	..	·3	246·0	252·2	+ 6·2	
·7	221·8	13·1	·8	244·0	..	..	..	42·8	244·2	247·6	+ 3·4	
38·5	205·4	9·3	·4	225·4	..	..	..	40·0	225·7	221·2	− 4·5	No observation from 5h 38·2m to 38·7m. 5 Differences before and 5 after the interruption.
41·2	192·9	19·1	·1	211·3	..	..	..	39·3	211·4	196·3	− 15·1	
·7	185·2	13·2	·0	202·8	..	..	..	36·8	203·0	191·8	− 11·2	
42·2	181·9	14·1	·0	199·0	..	..	..	·3	199·2	187·1	− 12·1	
·7	176·6	14·1	48·9	193·2	..	..	..	35·8	193·4	182·8	− 10·6	
43·2	170·8	16·5	·8	186·7	..	..	..	·3	186·9	178·2	− 8·7	
·7	166·5	15·3	·8	182·0	..	..	..	34·8	182·2	173·9	− 8·3	
44·2	160·2	16·2	·7	175·0	..	..	..	·3	175·2	169·6	− 5·6	
·7	149·8	12·1	·7	163·6	..	..	..	33·8	163·8	165·0	+ 1·2	
45·2	142·4	14·4	·6	155·4	0·0004	..	..	·3	155·6	160·8	+ 5·2	
·7	138·2	15·8	·5	150·8	..	..	..	32·8	151·0	156·4	+ 5·4	
46·2	132·9	14·4	·5	145·0	..	..	..	·3	145·1	152·2	+ 7·1	
54·2	86·8	30·5	47·5	94·1	..	..	..	24·3	94·2	92·2	− 2·0	No observations from 5h 48·7m till 6h 0·2m. 5 Differences before and 5 after the interruption.
6 2·2	32·2	9·8	46·5	34·7	0·0003	..	..	16·3	34·7	50·4	+ 15·7	
·7	35·4	10·7	·5	38·2	..	..	..	15·8	38·2	48·8	+ 10·6	
3·2	37·5	10·6	·4	40·4	..	..	..	·3	40·4	46·2	+ 5·8	
·7	36·6	10·3	·3	39·4	..	..	..	14·8	39·5	45·6	+ 6·1	
4·2	38·6	10·6	·3	41·6	..	..	..	·3	41·6	44·2	+ 2·6	
·7	41·5	11·2	·2	44·7	..	..	..	13·8	44·7	43·1	− 1·6	
5·2	43·7	9·0	·2	47·0	..	..	..	·3	47·1	42·0	− 5·1	
·7	42·4	10·5	·1	45·6	..	..	..	12·8	45·6	41·0	− 4·6	
6·2	42·1	10·2	·0	45·3	..	..	..	·3	45·3	39·9	− 5·4	
·7	39·5	10·1	·0	42·5	..	..	..	11·8	42·5	38·9	− 3·6	

I. Sidereal Time.	II. G.	III. $P.\ E.$	IV z.	V. G_z.	VI. log ρ^2.	VII. log R'^2.	VIII. ϵ.	IX. Sid. Time from Middle of Eclipse.	X. G_z*.	XI. G_z* Curve.	XII. Curve minus Observ.	Remarks.
h m			°				°	h m				
6 7·2	36·5	± 10·1	45·9	39·2	0·0002	0·0000	..	− 1 11·3	39·2	37·9	− 1·3	
·7	33·4	9·4	·9	35·9	..	..	..	10·8	35·9	37·0	+ 1·1	
8·2	30·2	10·0	·8	32·4	..	..	..	·3	32·5	36·1	+ 3·6	
·7	27·4	8·9	·7	29·4	..	..	..	9·8	29·4	35·3	+ 5·9	
9·2	28·6	12·5	·7	30·7	..	..	..	·3	30·7	34·6	+ 3·9	
·7	25·8	10·4	·6	27·7	..	..	..	8·8	27·7	33·9	+ 6·2	
10·2	26·2	10·5	·6	28·1	..	..	..	·3	28·1	33·1	+ 5·0	
·7	30·5	11·3	·5	32·7	..	..	..	7·8	32·7	32·6	− 0·1	
11·2	33·5	12·0	·4	35·9	..	..	..	·3	35·9	31·9	− 4·0	
·7	30·8	13·1	·4	33·0	..	..	..	6·8	33·0	31·3	− 1·7	
12·2	32·0	13·0	·3	34·3	..	..	..	·3	34·3	30·9	− 3·4	
·7	34·8	12·9	·3	37·3	..	..	..	5·8	37·3	30·4	− 6·9	
13·2	34·9	13·4	·2	37·4	..	..	..	·3	37·4	30·0	− 7·4	No observations from 6h 15·7m to 22·7. 5 Differences before and 5 after the interruption.
19·2	24·8	11·1	44·5	26·5	0·0001	..	..	0 59·3	26·5	26·0	− 0·5	
24·2	20·2	6·5	·0	21·5	..	..	..	54·3	21·5	24·9	+ 3·4	Mean of six Differences only.
48·2	0·6	7·6	41·5	0·6	..	..	..	30·3	0·6	..	..	6h 48·2m till 8h 30·2m. These values are very doubtful, since the moon's heat was not fully concentrated on the thermopiles (see page 485).
·7	0·9	7·9	·4	0·9	..	..	..	29·8	0·9	..	..	
6 49·2	− 1·1	7·1	·4	− 1·2	0·0000	..	..	− 0 ·3	− 1·2	..	..	
8 1·7	+ 6·5	15·5	36·2	+ 6·7	9·9995	..	..	+ 0 43·2	+ 6·7	..	..	
2·2	1·9	11·1	·2	2·0	..	..	..	·7	2·0	..	..	
·7	2·8	11·4	·2	2·9	..	..	..	44·2	2·9	..	..	
3·2	4·7	10·0	·1	4·8	..	..	..	·7	4·8	..	..	
·7	7·3	8·8	·1	7·5	..	..	..	45·2	7·5	..	..	
4·2	4·1	4·9	·1	4·2	..	..	..	·7	4·2	..	..	
·7	3·8	5·2	·1	4·8	..	..	..	46·2	4·8	..	..	
5·2	3·0	5·4	·0	3·1	..	..	..	·7	3·1	..	..	
·7	4·1	4·6	·0	4·2	..	..	..	47·2	4·2	..	..	
6·2	3·2	4·4	·0	3·3	..	..	..	·7	3·3	..	..	
·7	4·5	5·2	·0	4·6	..	..	..	48·2	4·6	..	..	
7·2	3·1	4·2	·0	3·2	..	..	..	·7	3·2	..	..	
·7	2·7	5·1	·0	2·8	..	..	..	49·2	2·8	..	..	
8·2	6·2	7·6	35·9	6·4	..	..	..	·7	6·4	..	..	
·7	10·4	11·9	·9	10·7	..	..	..	50·2	10·7	..	..	
9·2	8·2	12·9	·9	8·4	..	..	..	·7	8·4	..	..	
·7	7·2	13·6	·9	7·4	..	..	..	51·2	7·4	..	..	

I. Sidereal Time.	II. G.	III. $P.E.$	IV. z.	V. G_z.	VI. $\log \rho^2$.	VII. $\log R'^2$.	VIII. ϵ.	IX. Sid. Time from Middle of Eclipse.	X. G_z*.	XI. G_z*. Curve.	XII. Curve minus Observ.	Remarks.
h m			°				°	h m				
8 10·2	8·1	± 13·3	35·9	8·3	9·9995	0·0000	..	+0 51·7	8·3	..	..	
·7	7·9	13·3	·9	8·1	..	..	..	52·2	8·1	..	..	
11·2	8·5	13·3	·8	8·8	..	..	..	·7	8·7	..	..	
·7	5·2	14·0	·8	5·4	..	..	..	53·2	5·3	..	..	
12·2	4·1	14·5	·8	4·2	..	..	..	·7	4·2	..	..	
30·2	7·0	15·7	·4	7·2	9·9993	..	..	1 11·7	7·2	..	..	
·7	12·8	12·8	·4	13·2	..	..	..	12·2	13·1	12·6	− 0·5	
31·2	14·4	11·9	·4	14·8	..	..	..	·7	14·8	13·7	− 1·1	
·7	17·1	10·0	·4	17·6	..	..	..	13·2	17·6	14·9	− 2·7	
32·2	16·4	10·0	·4	16·9	..	..	..	·7	16·8	16·1	− 0·7	
·7	16·1	9·3	·3	16·6	..	..	..	14·2	16·5	17·6	+ 1·1	
33·2	15·8	9·4	·3	16·3	..	..	..	·7	16·2	19·1	+ 2·9	
·7	17·8	9·4	·3	18·3	..	..	..	15·2	18·3	20·8	+ 2·5	
34·2	21·5	6·4	·3	22·1	..	..	..	·7	22·1	22·5	+ 0·4	
·7	21·2	6·3	·3	21·8	..	..	..	16·2	21·8	24·3	+ 2·5	
35·2	23·7	7·1	·3	24·4	..	..	..	·7	24·3	26·1	+ 1·8	
·7	23·2	7·2	·3	23·8	..	..	..	17·2	23·8	28·0	+ 4·2	
36·2	29·4	12·8	·3	30·2	..	..	..	·7	30·2	30·0	− 0·2	
·7	37·3	14·9	·3	38·3	..	..	..	18·2	38·3	32·0	− 6·3	
37·2	44·0	16·3	·3	45·2	..	..	..	·7	45·2	33·9	− 11·3	
·7	43·8	16·4	·3	45·0	..	..	..	19·2	44·9	36·0	− 8·9	
38·2	43·9	16·3	·3	45·1	..	..	..	·7	45·1	38·1	− 7·0	
·7	47·6	16·7	·3	48·9	..	..	..	20·2	48·8	40·3	− 8·5	
39·2	49·8	15·3	·3	51·2	..	..	..	·7	51·1	42·6	− 8·5	
·7	46·5	19·6	·3	47·8	..	..	..	21·2	47·7	44·9	− 2·8	
40·2	48·5	19·5	·3	49·8	..	..	..	·7	49·8	47·2	− 2·6	
·7	57·7	21·7	·3	59·3	..	..	..	22·2	59·2	49·9	− 9·3	
41·2	59·8	22·5	·3	61·5	..	..	..	·7	61·4	52·2	− 9·2	
·7	59·5	22·2	·3	61·2	..	..	..	23·2	61·1	54·9	− 6·2	
42·2	57·6	21·8	·3	59·2	..	..	..	·7	59·1	57·1	− 2·0	
·7	61·9	21·1	·3	63·6	..	..	..	24·2	63·5	59·9	− 3·6	
43·2	67·3	20·7	·3	69·2	..	..	..	·7	69·1	62·4	− 6·7	
·7	69·5	21·2	·3	71·4	..	..	..	25·2	71·3	65·1	− 6·2	
44·2	70·7	20·8	·3	72·6	..	..	..	·7	72·5	68·0	− 4·5	
·7	78·6	10·2	·3	80·8	..	..	..	1 26·2	80·6	70·6	− 10·0	

I. Sidereal Time.	II. *G.*	III. *P. E.*	IV. *z.*	V. G_z.	VI. log ρ^2.	VII. log R'^2.	VIII. ϵ.	IX. Sid. Time from Middle of Eclipse.	X. G_z*.	XI. G_z* Curve.	XII. Curve minus Observ.	Remarks.
h m			°				°	h m				
8 45·2	79·1	± 9·8	35·3	81·3	9·9993	0·0000	..	+1 26·7	81·2	73·4	− 7·8	
·7	75·2	7·6	·2	77·3	..	..	..	27·2	77·1	76·1	− 1·0	
46·2	75·7	8·1	·2	77·8	..	..	..	·7	77·7	78·9	+ 1·2	
·7	74·8	7·8	·2	76·9	..	..	..	28·2	76·7	81·9	+ 5·2	
47·2	79·2	9·4	·2	81·4	..	..	..	·7	81·3	84·9	+ 3·6	
·7	83·6	9·5	·2	85·9	..	..	..	29·2	85·8	87·9	+ 2·1	
48·2	85·6	13·1	·3	88·0	..	..	..	·7	87·8	90·8	+ 3·0	
·7	85·0	13·0	·3	87·4	..	..	..	30·2	87·2	93·8	+ 6·6	
49·2	88·9	11·7	·3	91·4	..	..	..	·7	91·2	96·8	+ 5·6	
·7	94·4	12·9	·3	97·0	..	..	..	31·2	96·9	99·9	+ 3·0	
50·2	101·0	12·9	·3	103·8	..	..	..	·7	103·6	102·9	− 0·7	
·7	110·6	16·8	·3	113·7	..	..	..	32·2	113·4	106·0	+ 2·6	
51·2	120·5	22·9	·3	123·8	..	..	..	·7	123·6	109·1	− 14·5	
·7	131·4	23·0	·3	135·1	..	..	..	33·2	134·8	112·3	− 22·5	
52·2	137·6	24·4	·3	141·5	..	..	..	·7	141·2	115·3	− 25·9	
·7	141·8	24·3	·3	145·7	..	..	..	34·2	145·5	118·4	− 27·1	
53·2	145·5	23·1	·3	149·6	..	..	..	·7	149·3	121·8	− 27·5	
·7	147·5	21·0	·3	151·6	..	..	..	35·2	151·4	125·0	− 26·4	
54·2	149·2	19·3	·3	153·3	..	..	..	·7	153·1	128·5	− 24·6	
·7	155·1	19·6	·3	159·4	..	..	..	36·2	159·2	131·9	− 27·3	
55·2	155·9	19·2	·3	160·3	..	..	..	·7	160·0	135·4	− 24·6	
·7	152·8	19·5	·3	157·0	..	..	..	37·2	156·8	139·0	− 17·8	
56·2	148·3	17·4	·3	152·4	..	..	..	·7	152·2	142·2	− 10·0	
·7	146·6	16·0	·3	150·8	..	..	..	38·2	150·5	145·9	− 4·6	
57·2	145·5	15·4	·3	149·6	..	..	..	·7	149·4	149·4	0·0	
·7	147·2	16·5	·3	151·3	..	..	..	39·2	151·1	153·0	+ 1·9	
58·2	151·5	18·4	·3	155·7	..	..	..	·7	155·5	156·8	+ 1·3	
·7	158·8	15·3	·4	163·2	..	..	..	40·2	163·0	160·2	− 2·8	
59·2	165·9	12·5	·4	170·6	..	..	..	·7	170·3	164·1	− 6·2	
·7	165·1	12·2	·4	169·7	..	..	..	1 41·2	169·4	168·0	− 1·4	
9 0·2	171·4	11·7	·4	176·2	9·9992	..	..	·7	175·9	171·9	− 4·0	
·7	175·0	9·9	·4	179·9	..	..	..	42·2	179·6	175·8	− 3·8	
1·2	178·1	7·6	·4	183·1	..	..	..	·7	182·7	179·4	− 3·3	
·7	179·8	7·5	·4	184·9	..	..	..	43·2	184·6	183·5	− 1·1	
2·2	186·6	10·2	·4	191·9	..	..	..	·7	191·5	187·3	− 4·2	

I. Sidereal Time.	II. G.	III. $P. E.$	IV. z.	V. G_z.	VI. log ρ^2.	VII. log R'^2.	VIII. ϵ.	IX. Sid. Time from Middle of Eclipse.	X. G_z*.	XI. G_z* Curve.	XII. Curve minus Observ.	REMARKS.
h m			°				°	h m				
9 2·7	191·6	± 12·8	35·4	197·0	9·9992	0·0000	..	+ 1 44·2	196·6	191·2	− 5·4	
3·2	194·4	13·1	·4	199·9	..	..	..	·7	199·5	195·4	− 4·1	
·7	192·5	14·9	·4	197·9	..	..	..	45·2	197·5	199·2	+ 1·7	
4·2	191·4	15·6	·4	196·8	..	..	..	·7	196·4	203·3	+ 6·9	
·7	194·2	14·4	·5	199·6	..	..	..	46·2	199·3	207·8	+ 8·5	
5·2	194·3	14·4	·5	199·8	..	..	..	·7	199·5	211·8	+ 12·3	
·7	194·4	14·9	·5	199·9	..	..	..	47·2	199·5	216·0	+ 16·5	
6·2	191·9	17·3	·5	197·3	..	..	..	·7	197·0	220·2	+ 23·2	
·7	191·0	17·5	·5	195·4	..	..	..	48·2	195·1	224·9	+ 29·8	
7·2	190·0	16·7	·5	195·4	..	..	..	·7	195·1	228·9	+ 33·8	
·7	184·4	14·8	·5	189·6	..	..	..	49·2	189·2	233·3	+ 44·1	From $9^h\,7{\cdot}7^m$ till $9^h\,9{\cdot}2^m$ the rays of the moon were not quite concentrated on the piles, so that the values G from $9^h\,6{\cdot}2^m$ till $11{\cdot}2^m$ (both extremes included) are somewhat too small.
8·2	181·1	13·0	·5	186·2	..	..	..	·7	185·9	237·8	+ 51·9	
·7	191·8	20·3	·5	197·2	..	..	1·30	50·2	198·5	242·2	+ 43·7	
9·2	203·1	26·3	·5	208·8	..	..	·30	·7	210·1	247·0	+ 36·9	
·7	211·1	32·0	·6	217·2	..	..	·31	51·2	218·5	251·9	+ 33·4	
10·2	216·2	33·0	·6	222·4	..	..	·31	·7	223·8	256·9	+ 33·1	
·7	225·4	53·1	·6	231·9	..	..	·32	52·2	233·2	261·9	+ 28·7	
11·2	240·9	32·2	·6	247·8	..	..	·32	·7	249·3	266·6	+ 17·3	
·7	255·4	32·6	·6	262·8	..	..	·32	53·2	264·3	271·7	+ 7·4	
12·2	261·5	31·4	·6	269·0	..	..	·33	·7	270·7	276·7	+ 6·0	
·7	273·4	24·2	·6	281·3	..	..	·33	54·2	283·0	282·0	− 1·0	
13·2	284·9	13·4	·6	293·2	..	..	·34	·7	294·9	287·4	− 7·5	
·7	290·6	14·5	·7	299·0	..	..	·34	55·2	300·8	292·9	− 7·9	
14·2	294·3	15·9	·7	302·8	..	..	·35	·7	304·7	298·1	− 6·6	
·7	297·3	16·2	·7	306·0	..	..	·35	56·2	307·9	303·3	− 4·6	
15·2	305·5	14·5	·7	314·5	9·9991	..	·36	·7	316·3	308·8	− 7·5	
·7	312·7	12·8	·7	321·9	..	..	·37	57·2	323·8	314·1	− 9·7	No observations from 9^h $18{\cdot}2^m$ to $23{\cdot}2^m$. 5 Differences before and 5 after the interruption.
20·7	372·5	31·3	·8	383·5	..	..	·42	2 2·2	386·0	366·9	− 19·1	
25·0	415·8	8·5	36·0	428·3	..	..	·43	6·5	431·0	408·9	− 22·1	Mean of 7 Differences only.
27·2	414·2	11·9	·1	426·8	..	..	·47	8·7	429·6	427·0	− 2·6	No observation at 9^h $27{\cdot}2^m$. 5 Differences before and 5 after the interruption.
30·2	423·7	13·7	·2	436·7	9·9990	..	·50	11·7	439·6	448·3	+ 8·7	
·7	428·0	13·4	·2	441·3	..	..	·50	12·2	444·2	451·6	+ 7·4	
31·2	437·3	8·2	·3	450·9	..	..	·51	·7	453·9	454·7	+ 0·8	
·7	438·8	7·4	·3	452·5	..	..	·52	13·2	455·5	457·4	+ 1·9	
32·2	437·5	8·5	·3	451·1	..	..	·52	·7	454·1	460·2	+ 6·1	

I. Sidereal Time.	II. *G.*	III. *P. E.*	IV. *z.*	V. G_z.	VI. log ρ^2.	VII. log R'^2.	VIII. ϵ.	IX. Sid. Time from Middle of Eclipse.	X. G_z*.	XI. G_z* Curve.	XII. Curve minus Observ.	REMARKS.
h m			°				°	h m				
9 32·7	439·5	± 8·0	36·3	453·3	9·9990	0·0000	1·52	+2 14·2	456·3	463·4	+ 7·1	
33·2	440·0	8·0	·4	453·8	..	..	·53	·7	456·8	466·1	+ 9·3	
·7	439·1	8·3	·4	452·9	..	..	·53	15·2	455·9	469·0	+ 13·1	
34·2	439·0	8·4	·4	452·8	..	..	·54	·7	455·8	471·7	+ 15·9	
·7	438·9	8·4	·4	452·8	..	..	·55	16·2	456·0	474·3	+ 18·3	
35·2	444·3	14·8	·5	458·3	..	..	·55	·7	461·6	477·0	+ 15·4	
·7	451·1	20·0	·5	465·5	..	..	·56	17·2	468·8	479·7	+ 10·9	
36·2	455·1	21·3	·5	469·6	..	..	·57	·7	473·0	482·0	+ 9·0	
·7	463·7	24·9	·5	478·6	..	..	·57	18·2	482·0	484·3	+ 2·3	
37·2	468·1	23·6	·5	483·1	..	..	·57	·7	486·5	486·4	− 0·1	
·7	469·6	22·5	·6	484·8	..	..	·57	19·2	488·2	488·8	+ 0·6	
38·2	472·8	21·5	·6	487·8	..	..	·58	·7	491·5	490·9	− 0·6	
·7	478·2	19·0	·6	493·7	..	..	·58	20·2	497·3	493·0	− 4·3	
39·2	483·0	15·7	·6	498·5	..	..	·59	·7	502·3	495·0	− 7·3	
·7	487·1	12·6	·7	502·9	..	..	·59	21·2	506·6	496·9	− 9·7	
40·2	487·0	12·5	·7	502·8	..	..	·60	·7	506·5	498·6	− 7·9	
·7	485·6	11·6	·7	501·3	..	..	·60	22·2	505·1	500·3	− 4·8	
41·2	485·7	11·7	·7	501·4	..	..	·61	·7	505·2	502·0	− 3·2	
·7	484·4	10·5	·8	500·2	..	..	·62	23·2	504·1	503·7	− 0·4	
42·2	488·1	10·2	·8	504·1	..	..	·62	·7	507·9	505·1	− 2·8	
·7	493·6	9·5	·8	509·8	..	..	·62	24·2	513·7	506·8	− 6·9	
43·2	497·2	8·0	·9	513·7	..	..	·63	·7	517·6	508·2	− 9·4	
·7	499·1	7·3	·9	515·7	..	..	·63	25·2	519·6	509·8	− 9·8	
44·2	503·4	6·8	·9	520·1	..	..	·64	·7	524·1	511·1	− 13·0	
·7	506·9	5·3	·9	524·0	..	..	·64	26·2	527·9	512·5	− 15·4	
45·2	510·6	7·4	37·0	527·7	9·9989	..	·65	·7	531·6	513·8	− 17·8	
·7	511·0	7·1	·0	528·1	..	..	·65	27·2	532·0	514·9	− 17·1	
46·2	510·7	7·1	·0	527·8	..	..	·66	·7	531·8	516·0	− 15·8	
·7	510·0	7·7	·1	527·2	..	..	·67	28·2	531·3	517·0	− 14·3	
47·2	509·0	8·3	·1	526·1	..	..	·67	·7	530·2	518·0	− 12·2	
·7	506·6	9·1	·1	523·8	..	..	·67	29·2	527·8	518·9	− 8·9	
48·2	508·3	9·8	·1	525·7	..	..	·68	·7	529·7	519·6	− 10·1	
51·5	507·8	8·6	·3	525·4	..	..	·72	33·0	529·5	523·9	− 5·6	No observations from 9h 50·7m to 52·2m. 5 Differences before and 5 after the interruption.
54·7	507·2	10·6	·5	525·2	..	..	·75	36·2	529·4	526·9	− 2·5	
55·2	506·9	10·7	·6	525·2	..	..	·75	·7	529·4	527·2	− 2·2	

I. Sidereal Time.	II. G.	III. $P. E.$	IV. z.	V. G_z.	VI. $\log \rho^2$.	VII. $\log R'^2$.	VIII. ϵ.	IX. Sid. Time from Middle of Eclipse.	X. G_z^*.	XI. G_z^* Curve.	XII. Curve minus Observ.	REMARKS.
h m			°				°	h m				
9 55·7	505·8	± 9·8	37·6	524·0	9·9989	0·0000	1·76	+2 37·2	528·2	527·6	− 0·6	
56·2	506·3	10·0	·6	524·6	..	..	·76	·7	528·8	527·9	− 0·9	
·7	504·7	10·1	·7	522·9	..	..	·77	38·2	527·1	528·1	+ 1·0	
57·2	504·5	9·9	·7	522·6	..	..	·77	·7	526·9	528·3	+ 1·4	
·7	509·6	10·1	·7	528·1	..	..	·77	39·2	532·3	528·7	− 3·6	
58·2	508·1	10·4	·8	526·6	..	..	·78	·7	531·0	528·9	− 2·1	
·7	506·3	9·3	·8	524·8	..	..	·78	40·2	529·1	529·1	0·0	
59·2	510·4	10·7	·8	528·8	..	..	·79	·7	533·2	529·3	− 3·9	
·7	513·7	8·9	·9	532·5	..	..	·79	41·2	536·9	529·4	− 7·5	
10 0·2	515·3	8·4	·9	534·2	9·9988	..	·80	·7	538·6	529·8	− 8·8	
·7	509·3	14·0	·9	528·1	..	..	·81	42·2	532·3	529·9	− 2·4	
1·2	508·5	13·9	38·0	527·3	..	..	·82	·7	531·9	530·0	− 1·9	
·7	510·9	13·7	·0	530·1	..	..	·82	43·2	534·6	530·0	− 4·6	
2·2	512·9	14·4	·0	532·1	..	..	·82	·7	536·7	530·0	− 6·7	
·7	512·7	14·3	·1	532·0	..	..	·83	44·2	536·5	530·1	− 6·4	
3·2	514·3	13·4	·1	533·7	..	..	·83	·7	538·3	530·1	− 8·2	
·7	516·5	14·3	·2	535·9	..	..	·84	45·2	540·5	530·2	− 10·3	
4·2	516·2	14·1	·2	535·7	..	..	·85	·7	540·3	530·2	− 10·1	
·7	516·5	14·2	·2	536·0	..	..	·85	46·2	540·6	530·3	− 10·3	
5·2	517·7	14·3	·3	537·4	..	..	·86	·7	542·0	530·3	− 11·7	
·7	525·5	6·1	·3	545·6	..	..	·87	47·2	550·3	530·3	− 20·0	
6·2	527·6	4·8	·3	547·8	..	..	·87	·7	552·5	530·3	− 22·2	
·7	529·1	4·7	·4	549·5	..	..	·87	48·2	554·3	530·3	− 24·0	
7·2	529·1	4·7	·4	549·6	..	..	·87	·7	554·4	530·4	− 24·0	
·7	527·2	5·8	·4	547·8	..	..	·88	49·2	552·5	530·4	− 22·1	
8·2	525·8	7·7	·5	546·4	..	..	·88	·7	551·1	530·4	− 20·7	
·7	523·4	8·2	·5	543·9	..	..	·89	50·2	548·6	530·4	− 18·2	
9·2	522·4	7·9	·6	542·8	..	..	·90	·7	547·5	530·4	− 17·1	
·7	525·8	10·2	·6	546·7	..	..	·90	51·2	551·4	530·4	− 21·0	
10·2	526·5	10·3	·6	547·3	..	..	·91	·7	552·1	530·4	− 21·7	
·7	526·4	10·2	·7	547·3	..	..	·92	52·2	552·1	530·4	− 21·7	
11·2	525·9	10·2	·7	546·8	..	..	·92	·7	551·6	530·4	− 21·2	
·7	524·4	10·1	·7	545·3	..	..	·92	53·2	550·0	530·5	− 19·5	
12·2	524·3	10·0	·8	545·3	..	..	·93	·7	550·0	530·5	− 19·5	
·7	528·7	11·4	·8	550·0	..	..	·93	54·2	554·9	530·5	− 14·4	

I. Sidereal Time.	II. G.	III. $P. E.$	IV. z.	V. G_z*.	VI. log ρ^2.	VII. log R'^2.	VIII. ϵ.	IX. Sid. Time from Middle of Eclipse.	X. G_z*.	XI. G_z* Curve.	XII. Curve minus Observ.	REMARKS.
h m			°				°	h m				
10 13·2	531·3	± 9·4	38·9	552·7	9·9988	0·0000	1·94	+ 2 54·7	557·6	530·6	− 27·0	
·7	533·2	8·0	·9	554·9	..	..	·95	55.2	560·1	530·6	− 29·5	
14·2	529·4	12·6	·9	550·9	..	..	·95	·7	556·0	530·6	− 25·4	
·7	521·2	15·8	39·0	542·5	..	..	·95	56·2	547·5	530·7	− 16·8	
15·2	516·9	17·0	·0	538·0	9·9987	..	·97	·7	542·9	530·7	− 12·2	
·7	512·5	16·7	·1	533·5	..	..	·97	57·2	538·4	530·8	− 7·6	
16·2	511·6	16·5	·1	532·7	..	..	·97	·7	537·5	530·8	− 6·7	
·7	511·4	16·4	·2	532·6	..	..	·97	58·2	537·4	530·8	− 6·6	
17·2	513·8	18·4	·2	535·2	..	..	·98	·7	540·1	530·8	− 9·3	
·7	512·8	17·4	·2	534·3	..	..	·98	59·2	539·3	530·9	− 8·4	
18·2	511·1	17·1	·3	532·6	..	..	·98	·7	537·5	530·9	− 6·6	
·7	509·0	16·8	·3	530·4	..	..	·99	3 0·2	535·6	530·9	− 4·7	
19·2	508·4	17·2	·4	529·9	..	..	2·00	·7	535·0	530·9	− 4·1	
·7	507·0	19·4	·4	528·5	..	..	·01	1·2	533·5	530·9	− 2·6	
20·2	506·1	19·1	·4	527·7	..	..	·02	·7	532·7	530·9	− 1·8	
·7	502·1	22·1	·5	523·6	..	..	·02	2·2	528·5	531·0	+ 2·5	
21·2	498·0	22·4	·5	519·4	..	..	·02	·7	524·3	531·0	+ 6·7	
·7	495·5	21·9	·6	516·9	..	..	·03	3·2	521·9	531·0	+ 9·1	
22·2	489·5	17·5	·6	510·6	..	..	·03	·7	515·6	531·0	+ 5·4	
·7	483·6	11·9	·6	504·6	..	..	·04	4·2	509·4	531·0	+ 21·6	
23·2	482·1	10·9	·7	503·1	..	..	·05	·7	508·1	531·0	+ 22·9	
·7	479·2	9·3	·7	500·2	..	..	·05	5·2	505·2	531·0	+ 25·8	
24·2	480·3	9·6	·8	501·4	..	..	·06	·7	506·3	531·0	+ 24·7	
·7	484·5	8·9	·8	505·8	..	..	·06	6·2	510·7	531·0	+ 20·3	
25·2	487·5	10·3	·9	509·1	..	..	·07	·7	514·1	531·0	+ 16·9	
·7	491·2	6·7	·9	513·3	..	..	·07	7·2	518·3	531·0	+ 12·7	
26·2	492·1	5·9	·9	514·1	..	..	·07	·7	519·3	531·0	+ 11·7	
·7	494·1	7·3	40·0	516·3	..	..	·08	8·2	521·4	531·0	+ 9·6	
27·2	496·2	7·1	·0	518·7	..	..	·08	·7	523·8	531·0	+ 7·2	
·7	498·9	9·0	·1	521·6	..	..	·09	9·2	526·7	531·0	+ 4·3	
28·2	498·3	9·2	·1	521·0	..	..	·10	·7	526·2	531·0	+ 4·8	
·7	497·8	9·8	·2	520·6	..	..	·10	10·2	525·9	531·0	+ 5·1	
29·2	497·1	10·1	·2	520·0	..	..	·11	·7	525·3	531·0	+ 5·7	
·7	494·6	9·0	·2	517·4	..	..	·11	11·2	522·6	531·0	+ 8·4	
30·2	490·8	11·0	·3	513·5	9·9986	..	·12	·7	518·7	531·0	+ 12·3	

I. Sidereal Time.	II. G.	III. $P. E.$	IV. z.	V. G_z.	VI. $\log \rho^2$.	VII. $\log R'^2$.	VIII. ϵ.	IX. Sid. Time from Middle of Eclipse.	X. G_z*.	XI. G_z* Curve.	XII. Curve minus Observ.	REMARKS.
h m			°				°	h m				
10 30·7	488·8	± 11·8	40·3	511·4	9·9986	0·0000	2·12	+ 3 12·2	516·6	531·0	+ 14·4	
31·2	488·6	12·1	·4	511·3	..	..	·12	·7	516·5	531·0	+ 14·5	
·7	487·3	10·8	·4	510·1	..	..	·13	13·2	515·4	531·0	+ 15·6	
32·2	482·4	9·5	·5	505·1	..	..	·13	·7	510·2	531·0	+ 20·8	
·7	480·3	6·8	·5	502·9	..	..	·14	14·2	508·2	531·0	+ 22·8	
33·2	486·2	15·0	·6	509·3	..	..	·15	·7	514·5	531·0	+ 16·5	
·7	496·4	23·0	·6	520·1	..	..	·15	15·2	525·5	531·0	+ 5·5	
34·2	498·8	22·9	·7	522·6	..	..	·16	·7	528·1	531·1	+ 3·0	
·7	494·7	26·2	·7	518·4	..	..	·17	16·2	523·8	531·1	+ 7·3	
35·2	490·7	28·6	·7	514·2	..	..	·17	·7	519·6	531·1	+ 11·5	
·7	490·5	28·7	·8	514·1	..	..	·17	17·2	519·5	531·1	+ 11·6	
36·2	488·8	29·2	·8	512·5	..	..	·18	·7	518·0	531·1	+ 13·1	
·7	481·8	31·5	·9	505·3	..	..	·18	18·2	510·6	531·1	+ 20·5	
37·2	480·4	31·7	·9	504·0	..	..	·19	·7	509·3	531·1	+ 21·8	
·7	476·4	31·8	41·0	499·9	..	..	·20	19·2	505·3	531·1	..	The observations from 10^h 37^m to 10^h 47^m, being (through some unrecognized disturbance) much too low, were not utilized for the construction of the final curve.
38·2	465·5	28·7	·0	488·7	..	..	·20	·7	493·9	531·1	..	
·7	449·7	16·4	·1	472·1	..	..	·21	20·2	477·1	531·1	..	
39·2	439·9	12·4	·1	461·8	..	..	·21	·7	466·8	531·1	..	
·7	439·4	12·4	·2	461·4	..	..	·22	21·2	466·5	531·1	..	
40·2	436·1	14·8	·2	458·1	..	..	·22	·7	463·0	531·2	..	
·7	432·7	13·0	·3	454·5	..	..	·22	22·2	459·5	531·2	..	
41·2	433·4	13·9	·3	455·4	..	..	·23	·7	460·4	531·2	..	
·7	437·2	15·5	·4	459·5	..	..	·23	23·2	464·5	531·2	..	
42·2	440·4	18·1	·4	462·9	..	..	·24	·7	467·9	531·3	..	
·7	437·8	18·0	·5	460·3	..	..	·25	24·2	465·5	531·3	..	
43·2	438·5	17·8	·5	461·2	..	..	·25	·7	466·3	531·3	..	
·7	440·2	17·5	·6	463·0	..	..	·26	25·2	468·2	531·3	..	
44·2	445·3	16·4	·6	468·5	..	..	·26	·7	474·0	531·3	..	
·7	445·6	16·2	·7	468·9	..	..	·27	26·2	474·3	531·3	..	
45·2	447·7	14·0	·7	471·2	9·9985	..	·27	·7	476·5	531·4	..	
·7	449·9	13·6	·8	473·6	..	..	·27	27·2	478·9	531·4	..	
46·2	448·0	12·7	·8	471·7	..	..	·28	·7	476·9	531·4	..	
·7	447·5	12·4	·9	471·2	..	..	·28	28·2	476·5	531·4	..	
47·2	441·9	9·6	·9	465·4	..	..	·28	·7	470·7	531·5	..	
11 21·7	485·2	21·3	45·8	520·8	9·9984	..	·65	4 3·2	528·2	532·3	+ 4·1	

I. Sidereal Time.	II. G.	III. $P.E.$	IV. z.	V. G_z.	VI. log ρ^2.	VII. log R'^2.	VIII. ϵ.	IX. Sid. Time from Middle of Eclipse.	X. G_z*.	XI. G_z* Curve.	XII. Curve minus Observ.	REMARKS.
h m			°				°	h m				
11 22·2	487·0	± 21·3	45·8	523·0	9·9984	0·0000	2·66	+ 4 3·7	530·6	532·3	+ 1·7	
·7	490·8	20·1	·9	527·2	..	..	·67	4·2	534·8	532·3	− 2·5	
23·2	491·8	19·9	46·0	528·5	..	..	·67	·7	536·2	532·3	− 3·9	
·7	490·2	20·4	·0	527·0	..	..	·68	5·2	534·6	532·3	− 2·3	
24·2	493·6	17·6	·0	530·8	..	..	·68	·7	538·4	532·3	− 6·1	
·7	487·2	13·9	·1	524·1	..	..	·69	6·2	531·6	532·3	+ 0·7	
25·2	479·6	6·6	·2	516·0	..	..	·70	·7	523·6	532·3	+ 8·7	
·7	479·9	6·5	·2	516·5	..	..	·70	7·2	524·1	532·3	+ 8·2	
26·2	478·6	5·4	·3	514·7	..	..	·71	·7	522·3	532·3	+ 10·0	
·7	479·6	6·1	·4	515·0	..	..	·71	8·2	522·5	532·3	+ 9·8	
27·2	481·7	6·9	·4	519·0	..	..	·72	·7	526·7	532·3	+ 5·6	
·7	482·4	7·6	·5	520·0	..	..	·72	9·2	527·7	532·3	+ 4·6	
28·2	483·0	7·8	·6	520·8	..	..	·72	·7	528·5	532·3	+ 3·8	
·7	486·8	8·1	·6	525·0	..	..	·73	10·2	532·8	532·3	− 0·5	
29·2	489·8	8·1	·7	528·4	..	..	·73	·7	536·3	532·3	− 4·0	
·7	491·7	8·1	·7	530·8	..	..	·74	11·2	538·7	532·3	− 6·4	
30·2	490·3	10·3	·8	529·5	9·9983	..	·75	·7	537·4	532·4	− 5·0	
·7	492·8	9·8	·8	532·3	..	..	·76	12·2	540·3	532·4	− 7·9	
31·2	499·1	13·8	·9	539·4	..	..	·76	·7	547·4	532·4	− 5·0	
·7	501·5	12·9	47·0	542·0	..	..	·77	13·2	550·0	532·4	− 17·6	
32·2	500·7	13·1	·0	541·6	..	..	·77	·7	549·5	532·4	− 17·1	
·7	499·2	14·6	·1	540·0	..	..	·77	14·2	548·0	532·4	− 15·6	
33·2	502·3	15·7	·2	543·7	..	..	·78	·7	551·8	532·4	− 19·4	
·7	504·4	15·9	·2	545·9	..	..	·78	15·2	554·2	532·4	− 21·8	
34·2	503·5	16·2	·3	545·3	..	..	·79	·7	553·5	532·4	− 21·1	
·7	501·4	16·1	·3	543·0	..	..	·80	16·2	551·2	532·4	− 18·8	
35·2	499·5	19·7	·4	541·3	..	..	·80	·7	549·4	532·4	− 17·0	
·7	493·7	22·8	·5	535·2	..	..	·81	17·2	543·3	532·4	− 10·9	
36·2	488·9	20·1	·5	530·6	..	..	·82	·7	538·7	532·4	− 16·3	
·7	485·3	19·2	·6	526·5	..	..	·82	18·2	534·6	532·4	− 2·2	
37·2	483·8	19·3	·7	525·0	..	..	·82	·7	533·1	532·4	− 0·7	
·7	482·6	19·1	·7	523·8	..	..	·83	19·2	531·9	532·4	+ 0·5	
38·2	479·7	17·4	·8	521·0	..	..	·83	·7	528·9	532·5	+ 3·6	
·7	474·0	13·9	·8	515·0	..	..	·84	20·2	522·9	532·5	+ 9·6	
39·2	471·7	13·0	·9	512·6	..	..	·85	·7	520·7	532·5	+ 11·8	

I. Sidereal Time.	II. G.	III. $P. E.$	IV. z.	V. G_z.	VI. $\log \rho^2$.	VII. $\log R'^2$.	VIII. ϵ.	IX. Sid. Time from Middle of Eclipse.	X. G_z*.	XI. G_z* Curve.	XII. Curve minus Observ.	Remarks.
h m			°				°	h m				
11 39·7	474·1	± 14·3	47·9	515·4	9·9983	0·0000	2·85	+4 21·2	523·6	532·5	+ 8·9	
40·2	478·4	11·1	48·0	520·4	..	..	·86	·7	528·5	532·6	+ 4·1	
·7	481·5	7·8	·1	523·8	..	..	·87	22·2	532·2	532·6	+ 0·4	
41·2	477·5	7·9	·1	519·9	..	..	·87	·7	528·2	532·6	+ 4·4	
·7	476·2	8·0	·2	518·6	..	..	·87	23·2	526·9	532·6	+ 5·7	
42·2	476·4	8·0	·3	519·0	..	..	·88	·7	527·3	532·6	+ 5·3	
·7	476·1	8·1	·3	518·9	..	..	·88	24·2	527·2	532·6	+ 5·4	
43·2	474·2	6·9	·4	517·1	..	..	·89	·7	525·4	532·6	+ 7·2	
·7	472·2	8·6	·4	515·0	..	..	·90	25·2	523·4	532·6	+ 9·2	
44·2	470·3	9·3	·5	513·3	..	..	·90	·7	521·6	532·6	+ 11·0	
·7	465·1	7·2	·6	507·7	..	..	·91	26·2	515·9	532·6	+ 6·7	
45·2	461·9	7·7	·6	504·3	9·9982	..	·92	·7	512·4	532·6	+ 10·2	
·7	461·9	7·7	·7	504·6	..	..	·92	27·2	512·6	532·6	+ 10·0	
46·2	463·6	8·2	·8	506·7	..	..	·92	·7	514·8	532·6	+ 17·8	
·7	463·2	8·1	·8	506·4	..	..	·93	28·2	514·6	532·7	+ 18·1	
47·2	465·3	9·8	·9	509·0	..	..	·93	·7	517·2	532·7	+ 15·5	
·7	465·0	9·7	49·0	508·8	..	..	·94	29·2	517·0	532·7	+ 15·7	
48·2	462·3	10·5	·0	505·9	..	..	·95	·7	514·1	532·7	+ 18·6	
·7	464·9	10·3	·1	509·0	..	..	·95	30·2	517·2	532·7	+ 15·5	
49·2	466·2	9·7	·1	510·7	..	..	·96	·7	519·0	532·7	+ 13·7	
·7	469·7	9·8	·2	514·8	..	..	·96	31·2	523·2	532·7	+ 9·5	
50·2	469·4	10·2	·3	514·7	..	..	·97	·7	523·2	532·7	+ 9·5	

6. Explanation of the preceding Table.—Columns I. and II. After the remarks sect. 4 (page 486), no more need be said in explanation of these columns. Each value *G* is, unless anything to the contrary is mentioned in the last column, the mean of ten differences of eleven consecutive readings of the galvanometer.

Column III.—The probable errors in this column are based on the deviation of the single readings from the mean; they give, therefore, a tolerably clear idea of the steadiness of the apparatus. As was to be expected, the very considerable increase in sensitiveness of the thermocouples since 1884 has also increased the probable error of each heat-value *G*. Besides this, a very great increase is naturally to be perceived during the periods of the most rapid change of the lunar radiation. The mean probable errors, the absolute values as well as when expressed in per cents. of *G*, according to the phases of the eclipse stand as follows:—

Before totality.

	Average P.E. in Divisions of the Galvanometer Scale.	Average P.E. in °/₀ of G.
1. Before the first contact with the penumbra (18 observations), . .	± 8·11	± 1·47.
2. During the progress of the penumbra (81 obs.), ...	± 19·11	± 4·14.
3. During the progress of the shadow (52 obs.), ...	± 12·75	± 19·88.

After totality.

4. During the progress of the shadow (76 obs.), ...	± 14·86	± 22·64.
5. During the progress of the penumbra (88 obs.), ...	± 13·60	± 3·68.
6. After the last contact with the penumbra (132 obs.), ...	± 14·55	± 2·89.

The increase in the last column during the progress of the shadow is here, of course, chiefly due to the smallness of the values of *G*, the atmospheric and other disturbances (as, for instance, the errors of observation) being the same as during the other periods. The mean probable error of the whole series of 447 observations amounts to 14·55 divisions of the galvanometer-scale, or to 8·55 per cent. of the reading *G*. It appears doubtful whether the sensitiveness of the apparatus can be pushed much further if the mode of observing entirely in the open air be adhered to.

Columns IV. and V.—z is the Moon's true zenith-distance, and G_z the lunar radiation reduced to zenith by means of Dr. Copeland's table for the extinction of the lunar heat in our atmosphere, given in the *Philosophical Transactions* of the Royal Society for 1873, p. 598.

COLUMNS VI. AND VII.—The factors log. ρ^2 and log. R'^2 reduce the values G to the same distance of the Moon from the Earth and Sun, to those, namely, which correspond to $7^h\ 18{\cdot}5^m$ or the middle of the eclipse.

COLUMN VIII.—ϵ denotes the Moon's apparent elongation from the point opposite the Sun (– before, + after full Moon) calculated by the formula

$$\cos(\pi - \epsilon) = \sin D \sin \delta' + \cos D \cos \delta' \cos (A - \alpha'),$$

where
A = the Sun's right ascension,
D = the Sun's declination,
α' = the Moon's apparent right ascension,
δ' = the Moon's apparent declination.

This formula, where $(\pi - \epsilon)$ represents approximately the Moon's apparent illuminated phase, is given by Dr. Copeland in the Paper referred to above, p. 593.

COLUMN IX—Gives the sidereal times counted from the middle of the eclipse (– before, + after).

COLUMN X.—The values G_z* were obtained by multiplying those given in Column V. with the factors in Columns VI. and VII., and further with factors obtained from Dr. Copeland's phase-table (*l. c.* p. 605), by assuming simple proportionality. This correction for phase—the effect of which is but slight—was applied up to the first and after the last contact with the shadow (up to $5^h\ 28{\cdot}6^m$ and after $9^h\ 8{\cdot}4^m$) as was done in 1884.

COLUMNS XI. and XII.—The G_z* were now plotted down as ordinates with the times as abscissæ, and a curve was carefully drawn and read off. These final most probable quantities are given in Column XI., and their differences from the observations in Column XII. As mentioned before (*supra*, p. 486), the first value (observed at $3^h\ 22{\cdot}7^m$) and those obtained from $6^h\ 48{\cdot}2^m$ to $8^h\ 30{\cdot}2^m$ were excluded in drawing this final curve.

The two branches of the heat-curve are reproduced on Plates LIII. and LIV.

II.—*Construction of a Curve representing approximately the Change of the Moon's Light during the Eclipse.*

1. A short discussion of the heat-curve just obtained is more conveniently deferred till after the means have been supplied to compare it with a curve representing the variations of the lunar light during the eclipse. The dates for the computation of this curve were obtained as follows:—

The usual formulæ (Appendix to *Nautical Almanac* for 1836) furnished for the eclipse:—

Semi-diameter of shadow, ...	2558·8″
Semi-diameter of penumbra, ...	4511·8
Depth of penumbra, ...	1953·0
Diameter of Moon, ...	1905·8
Semi-diameter of Earth (as seen from the Moon), . .	3490·1
Semi-diameter of Sun (as seen from the Moon), . .	971·7

I now assumed the depth of the penumbra to be equal to $80 \times 24{\cdot}4'' = 1952$, and for the diameter of the Moon

$$78 \times 24{\cdot}4'' = 1903{\cdot}2'',$$

and divided the penumbra by concentric circles into 80 zones, so that the difference between the semi-diameters of two successive zones was

$$R^m - R^{m+1} = 24{\cdot}4,\ m = 0,\ 1,\ 2\ \ldots\ 80 \text{ and}$$

$$R^0 = 4511{\cdot}8 = \text{radius of penumbra,}$$

$$R^{80} = 2559{\cdot}8 = \text{assumed radius of shadow.}$$

The Moon was now supposed to move uniformly along a semi-diameter of the shadow, and the areæ successively cut off by the concentric circles computed by the formula

$$A_n{}^m = (\phi_n{}^m - \tfrac{1}{2} \sin 2\phi_n{}^m)\, \rho^2 + (\theta - \tfrac{1}{2} \sin 2\theta_n{}^m)\, R^{m2}$$

$$n = 0,\ 1,\ 2\ \ldots\ 78$$

$$m = 0,\ 1,\ 2\ \ldots\ 80$$

where $\rho = 951{\cdot}6$ = the assumed radius of the Moon, and consequently $\frac{2\rho}{78} = 24{\cdot}4$. The angles ϕ and θ were obtained from

$$\frac{\Delta_n{}^{m2} + \rho^2 - R^{m2}}{2\,\Delta_n{}^m \rho} = \cos \phi_n{}^m\,; \quad \frac{\rho \sin \phi_n{}^m}{R^m} = \sin \theta_n{}^m.$$

Here is
$$\Delta_n{}^m = R^m + \frac{39 - n}{39}\, \rho$$

the distance between the centre of the penumbra and the centre of the Moon.

Thus we obviously have $A_0^0 = 0$, or external contact, and $A_{78}^0 = 951{\cdot}6^2 . \pi$, or internal contact between moon and penumbra. Equally R^1, R^2 . . . R^{80} will respectively cut off the areæ :—

$$A_0^1 \ (=0),\ A_1^1,\ A_2^1\ \ldots .\ A_{78}^1\ (=951{\cdot}6^2{\cdot}\pi).$$

$$A_0^2 \ (=0),\ A_1^2,\ A_2^2\ \ldots .\ A_{78}^2\ (=951{\cdot}6^2{\cdot}\pi),\ \text{etc.}$$

$$A_0^{80} \ (=0),\ A_1^{80},\ A_2^{80}\ \ldots\ A_{78}^{80}\ (=951{\cdot}6^2{\cdot}\pi).$$

These areæ were rigorously computed for $m = 0, 10, 20, \ldots 60, 70, 80$, and, of course, $n = 0, 1, 2 \ldots 77, 78$ for each m, and the intermediate values interpolated. The portions of the Moon, lying successively in one special zone m, enclosed by the two concentric circles described with R^{m-1} and R^m will then obviously be

$$A_1^{m-1},\ A_2^{m-1} - A_1^m,\ A_3^{m-1} - A_2^m,\ \text{etc. till } A_{78}^{m-1} - A_{77}^m$$

where now $m = 1, 2, 3 \ldots 80$.

2. I next computed the uneclipsed areæ of the Sun (as seen from the Moon) for 80 points of equal distance, thus obtaining 82 values A_0^*, A_1^*, A_2^* . . . A_{80}^*, A_{81}^*, of which $A_0^* = 100$ denotes the full, and $A_{81}^* = 0$ the totally eclipsed Sun as seen from the Moon during the progress of the eclipse. These quantities, which represent approximately the luminosity of the successive penumbral zones—if we neglect the decrease of the Sun's light towards its limb—were plotted down in a curve, and the numbers corresponding to the middle point of each zone read off. These values

$$F_0\ (=100),\ F_1,\ F_2,\ \ldots\ F_{80},\ F_{81}\ (=0)$$

are the light-factors, with which the portions of the Moon which lie in the corresponding zones of the penumbra have to be multiplied in order to represent the Moon's luminosity during the progress of the eclipse. At any particular moment—that, for instance, of internal contact between Moon and penumbra, the Moon's luminosity will then be expressed by

$$A_{78}^1\ F_1 + (A_{77}^2 - A_{78}^1)\ F_2 + (A_{76}^3 - A_{77}^2)\ F_3 + \ldots$$

$$+ \left(A^m_{(79-m)} - A^{m-1}_{(79-m+1)}\right) F_m + \ldots + (A_2^{77} - A_3^{76})\ F_{77} + A_1^{78}\ F_{78}.$$

Thus 159 quantities were deduced which represent, with considerable approximation, the changes of the Moon's light during the progress of the eclipse, *i. e.* during the Moon's motion through the penumbra into the shadow.

3. It may be worth while once more to recapitulate the assumptions at variance with the facts which I made in order to simplify the computation. It was assumed that

a. the diameter of the Moon was 1903.2″, instead of 1905.8″;

b. the diameter of the shadow was 2559.8″, instead of 2558.8″;

c. the Moon moved uniformly along a semi-diameter of the penumbra;

d. the Sun's light was uniform;

e. the Moon's light was uniform.

I do not think that these deviations from reality seriously affect the accuracy of the result as far as our present purpose is concerned.

4. The values of the lunar heat taken from the final curve (Plates LIII. and LIV.) were next expressed in per cents. of the value of $4^{h\cdot}\ 9{\cdot}2^{m}$, viz. 658·0, and the two curves (light and heat) were drawn on the same piece of paper with the time as abscissæ and the light- and heat-values as ordinates. These curves are reproduced on Plate LV., the quantities on which they are based (to tenths of per cents., and from 5 to 5 minutes only) follow below in tabular form. For the sake of comparison I have added on the same plate and in the same Table the observations made and the light-curve computed in 1884. The time is counted from the middle of the eclipse in each case. It will be seen that I have added hypothetical values during totality, which are simply obtained by connecting in the most probable manner the two observed branches of the heat-curves, and which obviously can only give a somewhat vague idea of the course the curves would have taken had observing been possible.

In comparing the curves of 1884 and 1888 the difference of the magnitudes of the two eclipses must be borne in mind. I add, therefore, here the necessary data, from which it will be seen that the more recent eclipse lasted 12 minutes longer than its predecessor.

	OCT. 4, 1884. Sid. T.	JAN. 28, 1888. Sid. T.
First contact with penumbra,	19^h 41^m	4^h $26{\cdot}9^m$
,, ,, with shadow,	20 41	5 28·6
Beginning of totality,	21 40	6 29·4
Middle of eclipse,	22 26·5	7 18·5
End of totality,	23 13	8 7·6
Last contact with shadow,	0 12	9 8·4
,, ,, with penumbra,	1 12	10 10·0

TABLE II.

LUNAR LIGHT AND RADIANT HEAT DURING THE TOTAL ECLIPSES OF OCTOBER 4, 1884, AND JANUARY 28, 1888, EXPRESSED IN PER CENTS. OF FULL MOON RADIATION.

1884, October 4.		Time from Middle of Eclipse.	1888, January 28.		1884, October 4.		Time from Middle of Eclipse.	1888, January 28.	
☾'s light.	☾'s heat.		☾'s heat.	☾'s light.	☾'s light.	☾'s heat.		☾'s heat.	☾'s light.
..	..	− 3h 10m	100·0	100·0	0·0	1·0*	+ 0h 25m	0·7*	0·0
..	..	5	100·0	100·0	0·0	1·0*	30	0·6*	0·0
..	..	0	99·6	100·0	0·0	1·0*	35	0·5*	0·0
..	..	2 55	98·8	100·0	0·0	1·0*	40	0·4*	0·0
..	..	50	97·8	100·0	0·0	1·0*	45	0·4*	0·0
..	..	45	96·4	99·9	0·1	1·0*	50	0·4*	0·0
..	..	40	94·6	99·6	0·3	1·2	55	0·5*	0·1
..	..	35	92·5	98·7	1·2	1·5	1 0	0·6*	0·6
..	..	30	90·3	97·4	2·9	2·2	5	0·8*	1·8
..	..	25	87·3	95·2	5·4	4·0	10	1·4*	3·9
..	..	20	83·5	92·1	8·8	6·3	15	3·0	6·8
..	..	15	79·2	88·1	13·6	9·3	20	5·9	10·9
..	..	10	74·5	83·1	19·4	13·5	25	9·7	16·0
..	..	5	69·0	77·1	26·1	18·9	30	14·0	22·1
..	..	0	62·5	70·3	33·8	25·6	35	18·8	29·1
..	..	1 55	55·1	62·5	42·1	33·4	40	24·2	37·0
..	..	50	47·7	54·0	51·0	41·4	45	30·0	45·4
..	..	45	40·7	45·4	59·7	50·0	50	36·6	54·0
..	..	40	33·6	37·0	67·9	58·3	55	44·1	62·5
..	..	35	26·7	29·1	75·1	65·6	2 0	52·4	70·3
..	..	30	20·3	22·1	81·8	71·3	5	60·0	77·1
..	..	25	14·7	16·0	87·2	75·4	10	66·4	83·1
..	..	20	10·1	10·9	91·4	77·9	15	71·1	88·1
8·8	9·3*	15	7·0	6·8	94·7	79·8	20	74·8	92·1
5·4	7·3*	10	5·4	3·9	97·1	81·3	25	77·4	95·2
2·9	5·8	5	4·5	1·8	98·7	82·6	30	79·0	97·4
1·2	4·5	0	4·0	0·6	99·5	83·6	35	79·9	98·7
0·3	3·6	0 55	3·6	0·1	99·9	84·5	40	80·4	99·6
0·1	3·0*	50	3·3*	0·0	100·0	85·1	45	80·6	99·9
0·0	2·7*	45	3·1*	0·0	100·0	85·6	50	80·7	100·0
0·0	2·4*	40	2·9*	0·0	100·0	86·1	55	80·7	100·0
0·0	2·2*	35	2·7*	0·0	100·0	86·4	3 0	80·7	100·0
0·0	2·1*	30	2·5*	0·0	100·0	86·6	5	80·7	100·0
0·0	1·9*	25	2·4*	0·0	100·0	86·7	10	80·7	100·0
0·0	1·7*	20	2·2*	0·0	100·0	86·7	15	80·8	100·0
0·0	1·6*	15	2·0*	0·0	100·0	86·8	20	80·8	100·0
0·0	1·4*	10	1·8*	0·0	100·0	86·9	30	80·9	100·0
0·0	1·4*	− 0 5	1·6*	0·0	..	..	40	80·9	100·0
0·0	1·3*	0	1·4*	0·0	..	..	50	80·9	100·0
0·0	1·2*	+ 0 5	1·2*	0·0	..	..	4 0	81·0	100·0
0·0	1·1*	10	1·0*	0·0	..	..	10	81·0	100·0
0·0	1·0*	15	0·9*	0·0	..	..	20	81·0	100·0
0·0	1·0*	20	0·8*	0·0	..	..	30	81·0	100·0

NOTE.—The figures marked with an asterisk (*) are hypothetical only.

III.—*Discussion of the Observations.*

1. Decrease of heat before the first contact with the penumbra.

It might be alleged that this decrease is nothing but a result of the mode in which the final heat-curve has been constructed, and is as such of a purely arbitrary character, and not concordant with actual facts. A glance at Plate LIII. will, however, suffice to show that such can hardly be the case. I also add that I drew the curve as much as possible without any bias, keeping myself all the time carefully in ignorance of the different phases of the eclipse. I think it will have to be admitted that the curve could hardly have been drawn differently. Even the assumption that the decrease of heat did not begin until $4^h\ 20^m$ or 22^m would not agree with the observations, and could not be made without necessitating a sudden and inadmissible bend of the curve at about $4^h\ 23^m$. And further, if we assign any weight to the first observation of $3^h\ 22{\cdot}7^m$—even allowing it to be erroneous to a very considerable degree—the lunar heat would be run up, as it were, to over 670 at $4^h\ 20^m$, and to about 700 at $3^h\ 23^m$, or about an hour before the beginning of the eclipse. Thus a still earlier and, I think, altogether incredible decrease of heat would be brought about. Not that I consider the beginning of the decline at $4^h\ 9{\cdot}2^m$ as indicated by the finally adopted curve on Plate LV. any more probable. For I find that at that epoch the vertical distance of the Earth's centre from the nearest common tangent of Moon and Sun amounted to round 4685 miles. If we subtract from this the mean semi-diameter of the Earth, it would leave 725 miles as the approximate height of the Earth's atmosphere. This inadmissible amount shows that our observations are too much affected by disturbing influences as to admit of an accurate determination of the height at which the terrestrial atmosphere begins to absorb the solar heat. But they enable us to draw a lower limit for this height. It is evident, namely, that at $4^h\ 24^m$, or about 3 minutes before the first contact with the penumbra, the decrease of heat has definitely set in. And this indicates a height of heat-absorbing atmosphere of our Earth of not less than 190 miles. In any case, however, this result—though of considerable interest—must be received with caution until it has been confirmed by further observations.

2. During the progress of the penumbra the decrease of heat is decidedly more rapid than that of light. This must be chiefly due to the advance of the Earth's atmosphere, which would absorb a greater proportion of the heat- than of the light-rays. At first the heat-curve is not very steep. This was to be expected, as at first only those portions of the lunar surface are cut off which have the Sun near the horizon, and must, therefore, be considerably colder than the central portions. As the shadow advances these central parts of the Moon become rapidly

eclipsed. The heat-curve consequently grows steeper, and becomes more parallel with the light-curve. Finally, the decrease of heat slackens again, and the curve begins to inflect, as now only the colder areas of the lunar surface reflect towards the Earth.

3. At $6^h\ 2{\cdot}7^m$, or $26{\cdot}7^m$. before totality, the heat-curve intersects the light-curve, or, in other words, the emitted heat begins to preponderate over the reflected one. The equilibrium between both kinds of heat, therefore, takes place at $6^h\ 2{\cdot}7^m$, when the total amount measured is about 7·3 % of the Full Moon value. It is of interest to compare these facts with those observed during the former eclipse. Though we can only approximately tell the point of intersection in 1884 (since direct observations were not obtained) there cannot be much doubt that it fell at or near $21^h\ 11{\cdot}7^m$, or about 28 minutes before totality, when the total amount of heat was 9·2 % of Full Moon heat. The difference was to be expected, and is evidently mainly—if not exclusively—due to the greater magnitude of the more recent eclipse. It is, however, to be remarked here, that the heat observed in 1884 before totality is almost certainly too small, as observations were repeatedly interrupted by clouds. Thus it becomes probable, that the intersection between the two curves in 1884 took place somewhat earlier than assumed above, though, of course, an estimate which shall come nearer the truth cannot now be given.

4. In examining the hypothetical heat-curves during totality (see also page 505) the striking point is this, that during both eclipses the last residuum of heat must have been very small. The probable minimum falls in 1888 about two minutes before the end of totality with about 0·4 %, and in 1884 about ten minutes before the end of the total phase with about 1 %. This small residuum would evidently represent emitted heat only—its amount is so slight that its reality is somewhat doubtful. It also falls to such an extent below the probable error of the observations, that it would certainly not have been perceptible to our apparatus in its present construction had direct observing been practicable. Yet the character of the curves on Plate LV. seems to give sufficient evidence that the lunar heat was at no time actually reduced to zero. Referred to the times counted from the middle of the eclipse, we have in 1884 a lagging of the heat-minimum behind the light-minimum of about 35 minutes, in 1888 of about 45 minutes—a difference again due to the different durations of the two eclipses. From these remarks it would have been expected that the heat-values before the middle of the eclipse in 1884 should have been larger (instead of smaller) than the corresponding quantities of 1888. This anomaly may find its explanation in what has been said in the preceding paragraph about the uncertainty of the observations made in 1884 before the beginning of the total phase.

The point of intersection after totality in 1884 fell at $23^h\ 28{\cdot}5^m$ (or 62 minutes after the middle of the eclipse) with 1·8 °/₀ of heat; in 1888 it fell near $8^h\ 18{\cdot}5^m$, with 0·6 °/₀. The data of 1888 are constructed hypothetical ones; those of 1884 were actually observed.

5. After the point of intersection the heat-curve (of 1888) keeps almost parallel to the axis of the abscissæ for about six minutes; then it begins to rise again, at first slowly, then with increasing rapidity, keeping all the time at a considerably greater distance from the light-curve than before totality. At the moment of the last contact with the shadow, for instance, this distance amounts to $17\frac{1}{2}$ °/₀ against $6\frac{1}{2}$ °/₀ at the first contact. The same rapid rise was observed in 1884. But the curve of 1884 continued practically parallel to the light-curve till about 15 minutes after the last contact with the shadow, whereas the curve of 1888 assumes a peculiar S-shaped bend with the greatest elongation from the light-curve shortly after the last contact with the shadow. I am inclined to consider this bend as the result of some (most probably atmospheric) disturbance, and to believe the more parallel course in 1884 the more plausible one. This would mean that the above-mentioned difference between heat and light-curve ought to be reduced from $17\frac{1}{2}$ °/₀ to about 15 °/₀ against $9\frac{1}{2}$ °/₀ at the corresponding moment in 1884.

I need hardly add that such an atmospheric disturbance need not necessarily have occurred at the place of observation, but may have taken place in those regions of our atmosphere which were transversed by the solar rays before they reached the Moon.

6. About 16 minutes after the last contact with the shadow in 1884, and about 17 minutes after the corresponding contact in 1888 the increase of heat begins to become gradually less and less, and in 1888 all but ceases about 7 minutes before the last contact with the penumbra when the total amounts to 80·6 °/₀. Up to $1^h\ 30^m$ after this last contact this quantity increases only to 81 °/₀ of Full Moon heat. In 1884 the Moon's heat measured 38^m after the last contact with the penumbra was 86·8 °/₀ of the Full Moon value, so that, generally speaking, a remarkable agreement between the observations has been established. In detail, however, there exists a considerable difference. For whereas in 1888 the heat-curve—as indicated before —remains practically parallel to the light-curve from 7 minutes before the last contact with the penumbra, it continued to rise slowly but unmistakably in 1884 till about 14 minutes after the end of the eclipse, and only then showed some approach to parallelism to the light-curve. It would be difficult to say which of the two courses is the more probable one. A glance at Plate LIV. leads, however, to the following consideration in favour of the course of 1884. From this plate it is obvious that at about $8^h\ 10^m$ some (probably atmospheric) disturbance set in,

which, gradually increasing, ended (as far as observed) in reducing the lunar heat to 460 divisions of the galvanometer-scale shortly after $8^h\ 30^m$. Unfortunately I then stopped observing for 30 minutes, so that the recovery of the curve (which certainly must have taken place during this interruption) was not recorded. The character of the curve depends, therefore, essentially on the observations obtained after the interruption, and it is not unlikely that all these last observed quantities are still to some extent affected by the preceding disturbance, and, consequently, somewhat too small.

7. A satisfactory explanation of the deficiency of lunar heat after the end of the eclipse, in spite of the rapid fall to almost zero during the first half of it, I have as yet been unable to find. One fact, however, which may have some bearing on the question I may here mention, viz. that the heat-values of 1884 and 1888 corresponding to the last contact with the shadow and to the last contact with the penumbra seem to be inversely proportional to the times elapsed since the beginning of the two eclipses. We obtain, namely, under the assumption of such a proportionality for the heat at these two epochs in 1884, the figures 38·2 °/$_\circ$ and 83·9 °/$_\circ$, while the actually observed quantities were 41·4 °/$_\circ$ and 85·2 °/$_\circ$. If this proportionality were actually established—which is at present not the case as far as my observational material goes—it would seem to indicate that the amount of lunar heat transmitted by our atmosphere depends in some way on the amount previously absorbed. The facts would perhaps have to be imagined as follows. The heat immediately reflected by the Moon passes almost undiminished through the atmosphere, and thus causes the rapid rise after totality, while the emitted heat is largely absorbed, so much the more the cooler the atmosphere is. Thus this absorbed quantity of heat increases steadily with the progress of the eclipse; it reaches a maximum towards the end of totality (or, in other words, the total measured becomes a minimum at this epoch) and begins then steadily to decrease again. The heat measured after the end of the eclipse falls thus short of the Full Moon value by the amount of emitted heat which the atmosphere has absorbed, and rises slowly until the atmosphere is, so to speak, saturated, or the maximum of possible absorption has taken place, *i. e.* until the quantity of heat corresponding to Full Moon has been reached. The total heat measured after an eclipse must thus be inversely proportional to the duration of an eclipse. If the above reasoning holds good, the gradually rising heat-curve of 1884 would be the more probable one. It is well known that the idea of a very considerable absorption of the lunar heat by our atmosphere was familiar to Sir John Herschel, as seen from the following remarks (*Outlines of Astronomy*, 1873, p. 285):—“Though the surface of the Full Moon exposed to us must necessarily be very much heated, . . . yet we *feel* no heat from it. . . . No doubt, therefore, its heat (conformably to what is observed

of that of bodies heated below the point of luminosity) is much more readily absorbed in transversing transparent media than direct solar heat, and is extinguished in the upper regions of our atmosphere, never reaching the surface of the Earth at all. Some probability is given to this by the *tendency to disappearance of clouds under the Full Moon*, [the italics are Sir John's] a meteorological *fact* (for as such we think it fully entitled to rank), for which it is necessary to seek a cause, and for which no other rational explanation seems to offer."

8. Another explanation of our anomaly might be based on the following paragraph from E. Neison, *The Moon* (1876), p. 35:—

"Hitherto no reference has been made to a question of very considerable influence in the consideration of the questions connected with the lunar surface, and that is with regard to purely local atmospheric conditions; for from a number of different observations it has been considered that from local action some vapours may rise from the surface and play an important part in the questions connected with selenography. Reasoning from the known condition of the material constituting the terrestrial surface, it seems not unlikely that when exposed to the greater temperature to which it has been found that the surface of the Moon is in part exposed, some such local atmospheric conditions may well arise; and that a purely local covering to the surface may well occur in the interior of a deep formation, from the presence of some constituent of the surface, first expelled by the heat and then reabsorbed on cooling. Of the terrestrial surface strata, for example, exposed to the condition under which the Moon exists, few, if any, would be found where this might not be expected to occur in some degree, and such would be most naturally supposed to occur in the interior of the deeper lunar formations where the last influence of any aqueous vapour might be expected to be manifested."

From this remark we should conclude that during the progress of an eclipse a steady absorption of vapour would take place, by which some heat would be developed. After the eclipse the atmosphere would emanate again, and during this process a certain amount of heat would be consumed or bound until the whole of the atmosphere is set free. By this amount of heat the total measured after the eclipse should fall short of the Full Moon value. Under these circumstances the heat-curve of 1888 after the last contact with the penumbra would be the more probable one. For it should run parallel to the axis of the abscissæ until the lunar vapourous atmosphere is fully developed, and should then rather suddenly rise up to the Full Moon value.

It may, of course, be possible that both the hypotheses discussed hold good and are together adequate in bringing about the observed anomaly.

The above theories I only mention tentatively and with considerable diffidence. Yet any attempt at explaining a so far unexplainable phenomenon may, I think, be of some use for future investigations.

CONCLUSION.

In conclusion I enumerate a series of observations which the preceding pages have shown to be decidedly desirable and in part possible for the same apparatus —observations which, as far as feasible, I have already begun, and shall lay before the public when tangible results have been obtained.

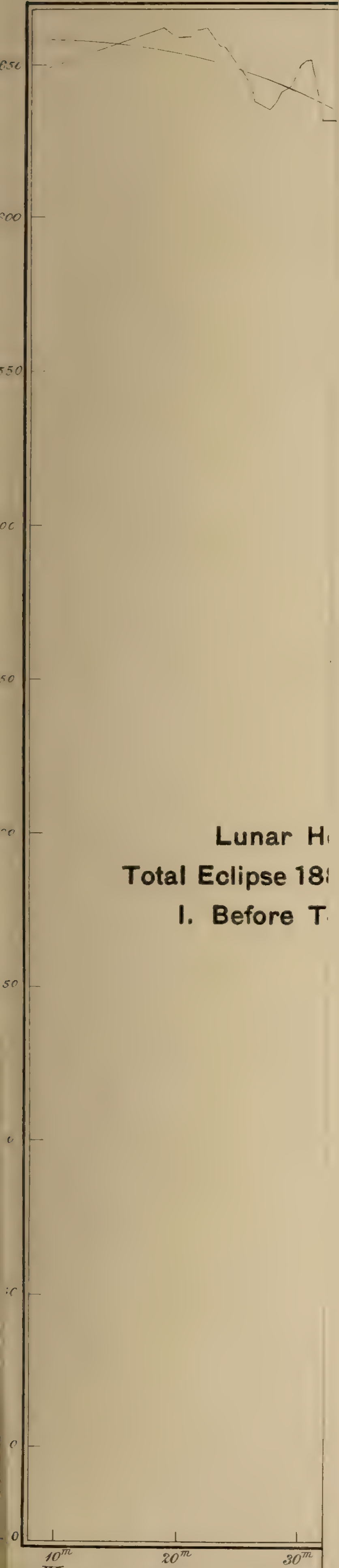
a. The debatable decrease of heat before the commencement of the eclipse requires confirmation or the reverse as the case may be. The best way to obtain this will consist in observing the near approaches of the Moon to the Earth's shadow—or in observing and discussing the lunar heat at Full Moon on every available occasion.

b. Observations during totality are much needed. I now think that with some precautionary modifications our apparatus may well yield reliable results, and I shall certainly try to obtain them during the next favourable eclipse.

c. The heat after the last contact with the penumbra requires careful measuring during eclipses differing as much as possible in magnitude.

d. It is not unlikely that the behaviour and nature of lunar heat may be recognized if eclipse-observations are carried on through glass. As far as I know, such observations were only made by Professor Langley on one occasion during totality; yet detailed and systematically obtained results appear necessary.

e. Finally, the varying radiation of different parts of the lunar surface—which may have caused many of the irregularities in the results which form the subject of the present paper—requires systematic observing. But this will necessitate either a thorough modification of our apparatus, or perhaps the use of radically different methods of observation.



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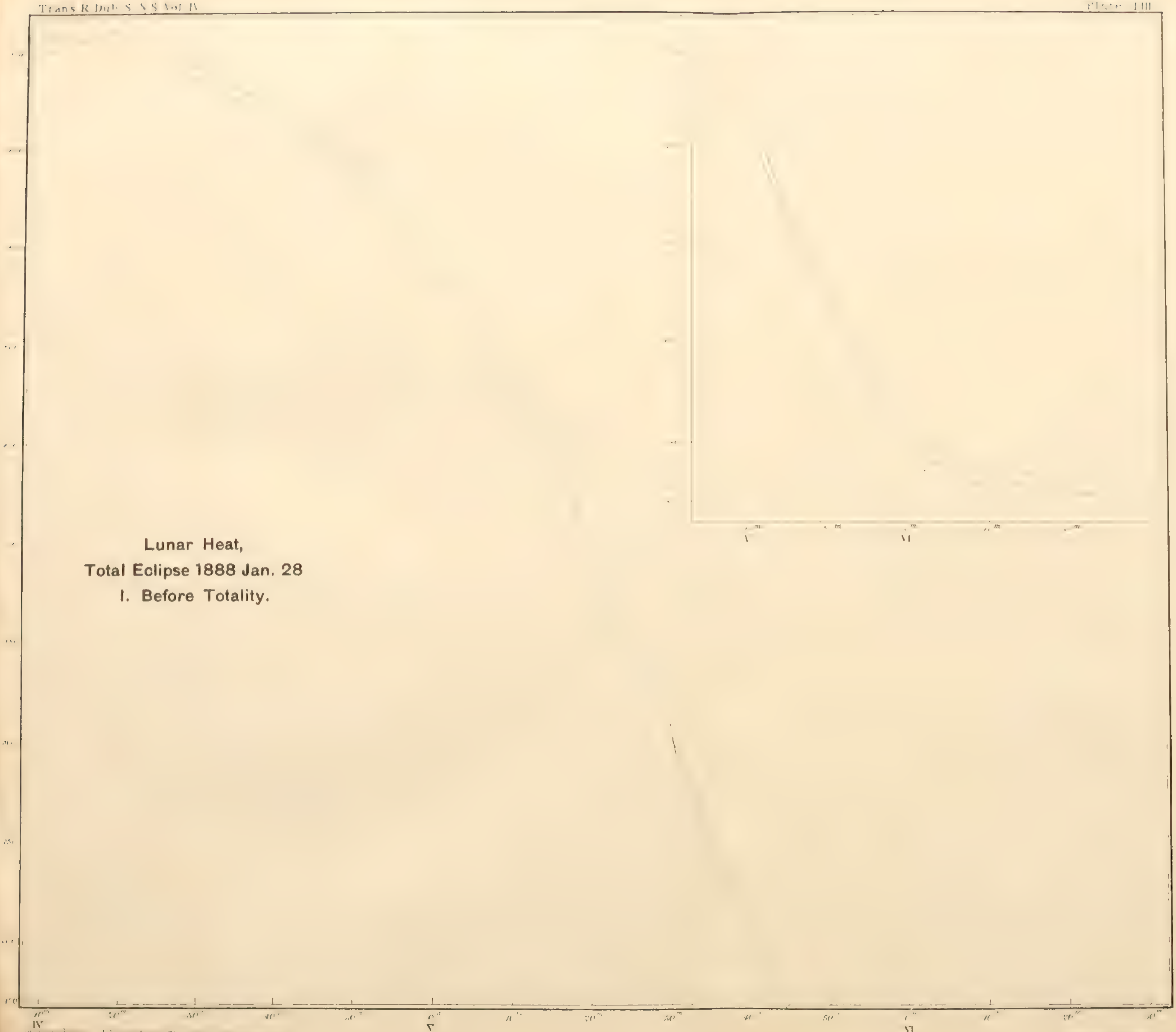
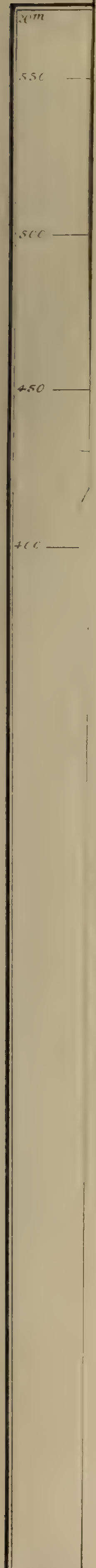
Total Eclipse 18
I. Before T

IV
Otto Boeddicker del Birr Castle Observat

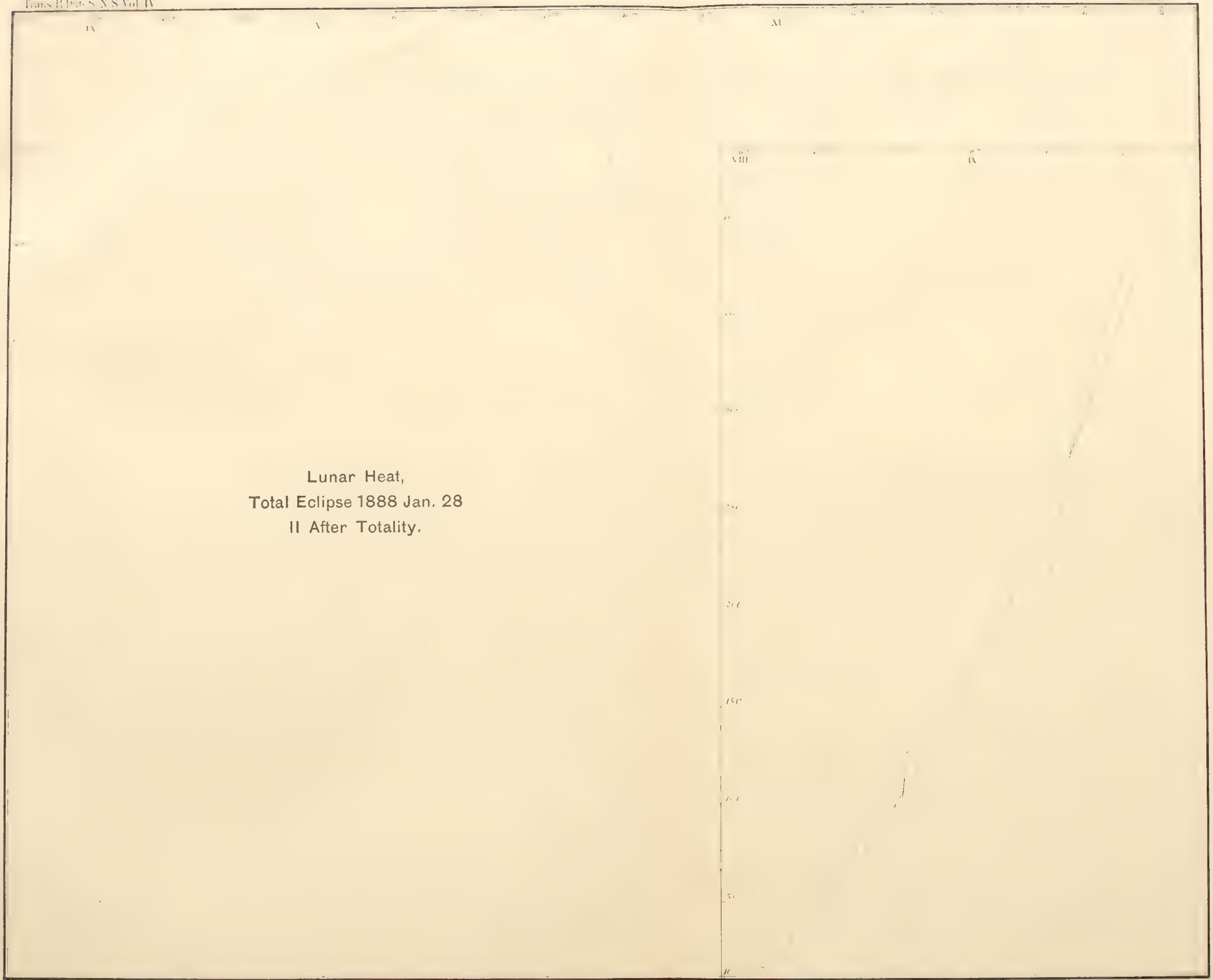


Lunar Heat,
Total Eclipse 1888 Jan. 28
I. Before Totality.

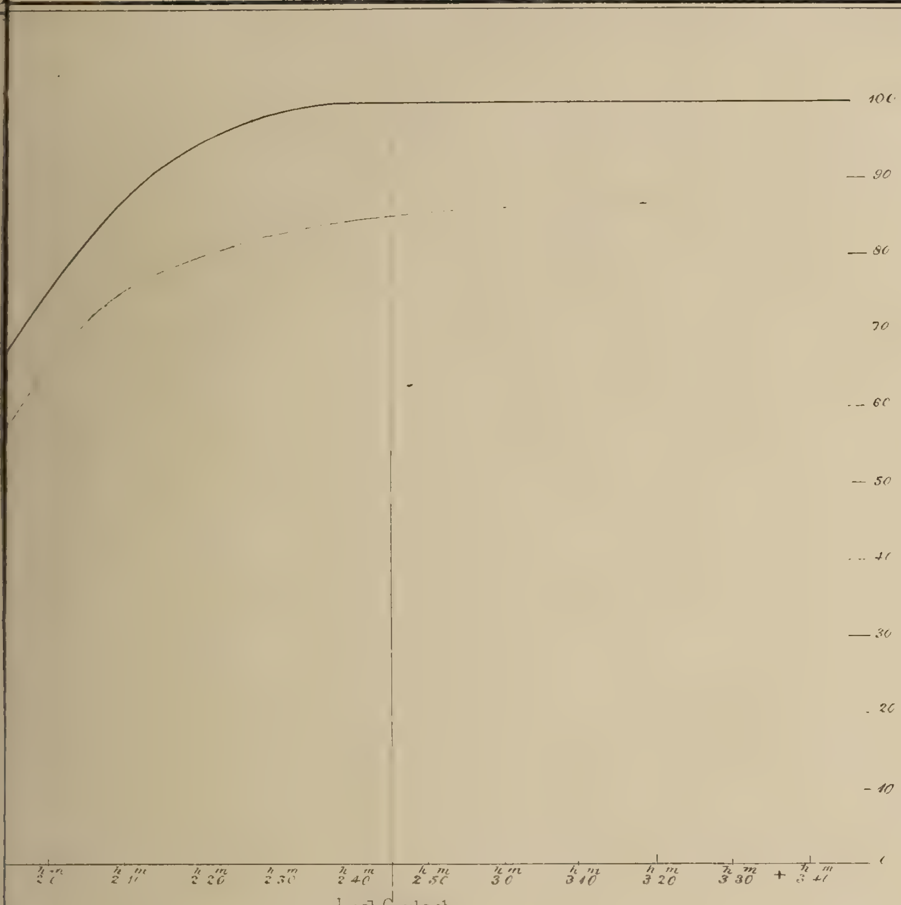
Trans. R



Otto B



Lunar Heat,
Total Eclipse 1888 Jan. 28
II After Totality.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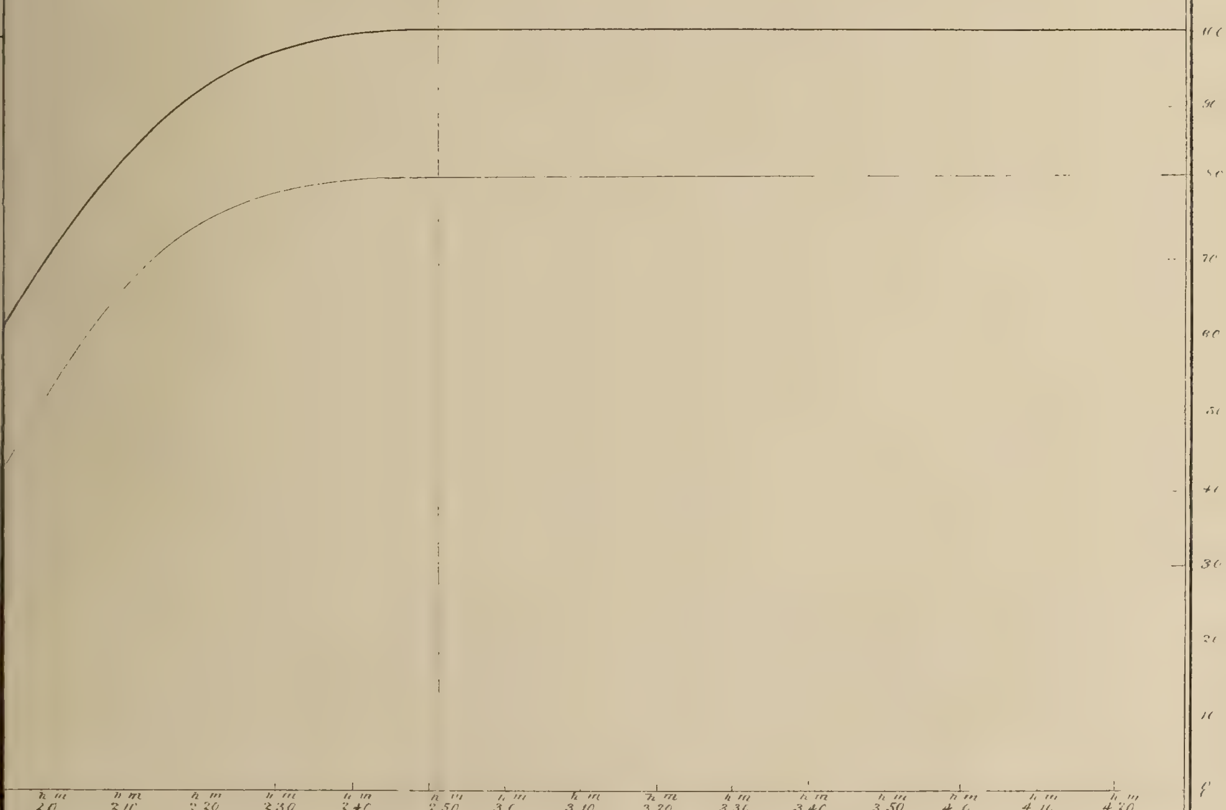
3 20
3 30
3 40
Last Contact
with Penumbra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Last Contact

Fig. I. Total Lunar Eclipse, 1884 October 4.

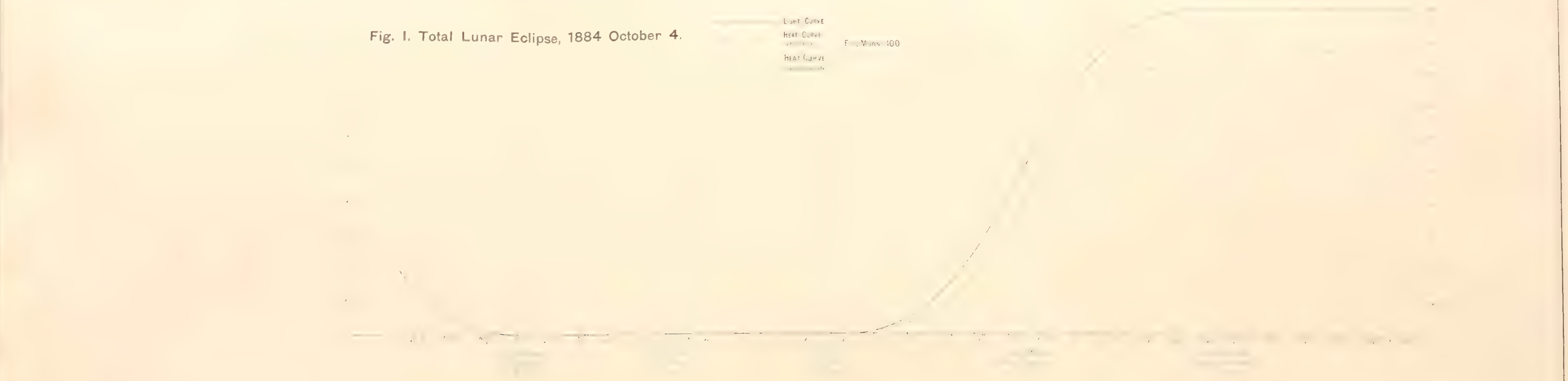
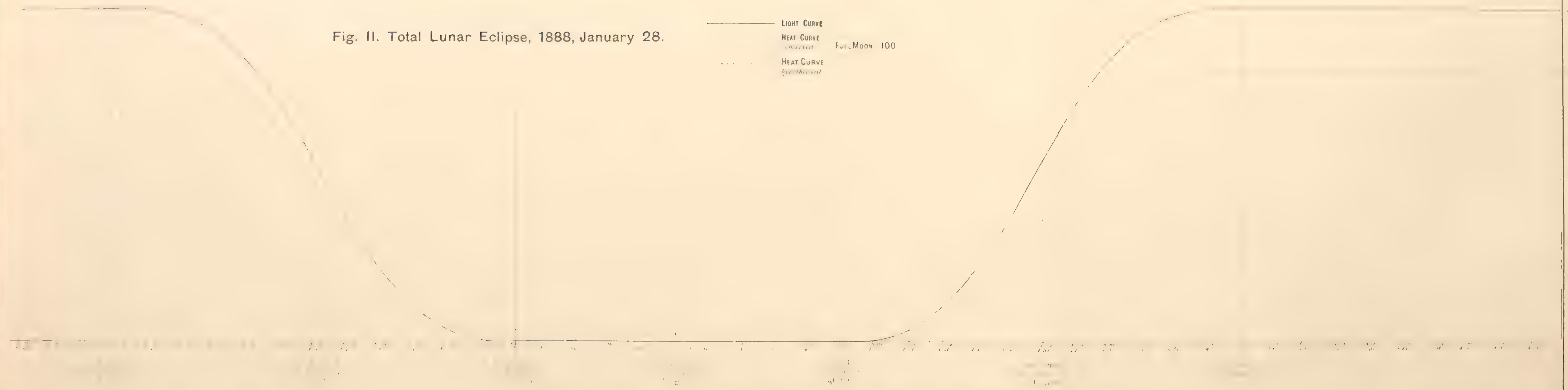


Fig. II. Total Lunar Eclipse, 1888, January 28.



X.

THE SLUGS OF IRELAND.

By R. F. SCHARFF, Ph.D., B.Sc., Keeper of the Natural History Museum, Dublin. Plates LVI. & LVII.

[Read March 9, 1891.]

The term "Slug," used in the ordinary sense, is applied to snails without an external shell. Anatomically, the slugs cannot be grouped into one distinct family apart from the snails. Even of the few genera inhabiting Ireland, *Limax*, *Agriolimax*, and *Amalia* must be placed in one family with the Helices, to which they are much more closely related than they are to *Arion* and *Geomalacus*, the two other Irish genera of slugs.

From a systematic point of view a description of these animals, leaving unmentioned the closely-related snails, may seem rather unscientific, but this work has been undertaken chiefly with a view of solving some of the difficulties regarding the distribution of terrestrial animals; and land snails having been known to be transported by sea, as has been shown by Darwin (*Origin of Species*, 6th ed., p. 353), are of less importance in this respect than slugs. The sea, which is the principal means of communication for other animals and plants between mainland and island, forms an almost impassable barrier for slugs, sea-water being deadly both to their eggs and themselves; therefore, if we find the slugs of mainland and island agreeing in anatomical characters, we may generally conclude that the island must have had a land connexion with the mainland at some time or other, and the more closely related the forms are, the more recent must have been this connexion.

The slugs of Ireland are very closely related, and in most cases are identical with those on the Continent of Europe. It is not my intention, however, to enter in this Paper more fully into the cause of the geographical distribution of slugs, as I propose to deal with the question in a subsequent communication.

Until quite recently, the tongue, or radula, of Mollusca has formed one of the chief characters in the classification, and the separation of one species from another. Specific distinction was based almost entirely on external characters and on

the structure of the radula; and new species have, in consequence, made their appearance in overwhelming numbers. Simroth (38) changed this unfortunate state of things by the production of an elaborate treatise on the German slugs, in which he bases his classification chiefly on the form of the reproductive organs and the intestine. He showed that the radula is subject to much individual variation, and that it is, perhaps, the most unsuitable portion of the slug's body for the purpose of classification. By his anatomical investigations he was enabled to reduce considerably the number of European species, as given in such a recent work as that of Westerlund (44). Among a number of species of *Limax* mentioned in the latter work, fifteen supposed genuine species proved, on examination of the internal organs, to be mere varieties of *Limax maximus.*

Slugs are not alone of importance as regards the geographical distribution of animals. I hope to be able to show in a separate chapter that their colour has an important bearing on the subject of colouring in animals generally.

Thompson, in his *Natural History of Ireland* (43), mentions nine species of slugs as occurring in this country. In the most recent list of Irish Mollusca published in 1888, by Taylor and Roebuck (42), this number has been increased to ten, but one of these, as I shall endeavour to show later on, is only a variety. I shall now add four species to the list of Irish slugs, one of which, however, has already been recorded by Roebuck (35), in the *Journal of Conchology*. All these thirteen species, with the exception of one, are also found in Great Britain. This one species, viz. *Geomalacus maculosus*, is not only absent from Great Britain, but also from France and Germany. It appears again in Northern Spain, in the province of Asturias. In Ireland it has hitherto only been found in the County Kerry. This part of Ireland has yielded so many peculiar animals and plants that it deserves very much more attention than it has hitherto received. A thorough scientific investigation of that interesting county would, no doubt, reveal a number of forms new to the British fauna and flora.

The thirteen species of Irish slugs belong to five genera, viz. *Limax*, *Agriolimax*, *Amalia*, *Arion*, and *Geomalacus*. In most of the British text-books, the three first are united under the genus *Limax*, but the reasons for separating them will be found under the headings of the respective genera. Lessona and Pollonera (21), and others, have placed the very common Irish slug *Limax marginatus* (= *arborum*) in a separate genus, *Lehmannia*, but I have not thought it advisable to adopt this subdivision of the remaining species of Limax.

The species of the three first genera can be very readily distinguished from those of the genus *Arion*, by the absence of the caudal gland. This gland is present in *Geomalacus*, but it is not nearly so conspicuous as in *Arion*, in which its triangular opening at the end of the body is well seen.

The colour of the mucus is not of very great importance, but it is rather

characteristic in *Amalia carinata* and *Agriolimax agrestis*, being always tough and sticky in the former, and milky in the latter.

The presence of dark lateral bands in most slugs from the very day of their birth, has induced Simroth (38) to regard them as an ancestral character; and, in referring to them, he speaks of the ancestral bands ("Stammbinde"). I merely use the term "lateral bands," although in many cases there appear, besides the original ones, two inner bands, one on each side of the median lighter stripe. These inner bands are separated from the lateral bands by a light stripe, and another similar stripe is on the outer side of the lateral bands. Thus, we distinguish band and stripes—the former dark, the other light in colour.

Simroth, in his monograph (38), has placed much weight in the classification of slugs on the nature of their food. However, my own investigations tend to show that there are fungus-eating species among the Limaces as well as the Arions, whilst most species are not particular as to what sort of food they get. Occasionally they all turn carnivorous, and cannibalism is of frequent occurrence.

The plan adopted in this Paper is to give a general concise synopsis of the various genera and species. Under the heading of each species are paragraphs dealing with: 1, External characters; 2, Anatomy; 3, Reproduction; 4, Habitat; 5, Food; 6, General Distribution. The anatomical part has been curtailed to a considerable extent, and only the general outlines of the reproductive organs have been mentioned, which are sufficient in all cases to distinguish one species from another. More elaborate accounts on the general anatomy will be found in Nunneley's (31) and Simroth's (38) works. Neither the shell nor the radula are mentioned, as they do not afford such easy and reliable evidence in the identification of the species as the reproductive organs.

The only papers ever published on Irish slugs are those of the Rev. B. J. Clarke (3), and Professor Allman (1). Although the former is exhaustive as far as it goes, it deals only with what was then believed to come under the head of the genus *Limax*. Professor Allman was the first to describe *Geomalacus maculosus*. The subsequent publications containing reference to Irish slugs are more of the nature of lists.

In Forbes and Hanley's *History of British Mollusca* (9), a few references are made to Irish slugs; and Thompson, in his *Natural History of Ireland* (43), gives a complete list of the species with which he was acquainted. A Paper by Taylor and Roebuck, entitled "Authenticated materials towards a Land and Freshwater Molluscan Fauna of Ireland" (42), contains the most recent list of slugs, with a good many records of localities from all parts of the country. For the past few years Messrs. Taylor and Roebuck have had in preparation a *Monograph of the Land and Freshwater Mollusca of the British Fauna*, which no doubt, will contain a good deal of useful information on the distribution and

variation of slugs. Mr. Roebuck, especially, has for several years made slugs his principal study, and has worked with great energy in extending our information as regards their distribution in all parts of Great Britain and Ireland. Before writing this Paper I consulted Messrs. Taylor and Roebuck, who in consideration of my only dealing with the most neglected portion of the British Islands, kindly promised their support and assistance in my work. The six volumes of the *Journal of Conchology* originated by J. W. Taylor contain a large number of references and records of Irish slugs.

The most important Memoirs on European continental slugs are those of Simroth (38) and Lessona and Pollonera (21). The former chiefly deals with the German forms, and the latter with the Italian. As regards the French slugs, Moquin-Tandon's (26) work is still the most reliable. Although more recent observers have added a good many new species, and even genera to the French Fauna, most of them have to be accepted with great caution.

In concluding these preliminary remarks, I must express my sincerest thanks to Messrs. A. G. More, F. W. Moore, J. R. Redding, G. Barrett-Hamilton, H. B. Rathborne, G. H. Carpenter, Rev. A. H. Delap, and Miss Warren, for specimens, and Messrs. Taylor, Hanitsch, Pollonera, and Simroth, for kind advice, or literary help. The latter was good enough to submit to me part of the proof of his forthcoming memoir on the slugs of Portugal and the Azores, which will appear during the course of the present year.

SYNOPSIS OF THE IRISH GENERA.

A.—Slugs without caudal gland. Pulmonary opening behind the middle of the mantle = *Limax*, *Agriolimax*, *Amalia*.

I.—Mantle with concentric wrinkles = *Limax*, *Agriolimax*.

a. Lateral bands, or a band of spots present, = *Limax*.
b. Lateral bands absent = *Agriolimax*.

II.—Mantle granulated, and with deep horse-shoe shaped groove, = *Amalia*.

B.—Slugs with caudal gland. Pulmonary opening in front of the middle of the mantle = *Arion*, *Geomalacus*.

I.—Caudal gland placed longitudinally = *Arion*.
II.—Caudle gland placed transversely = *Geomalacus*.

GENUS I.—**Limax.** (Linné, 1758).

Body elongated, keeled towards the tail; wrinkles longitudinal on body, concentric on mantle. Longitudinal bands or bands of spots on body and mantle always present in adult; no caudal gland. Pulmonary opening behind middle

of mantle. Reproductive pore near base of upper tentacles. There is a solid internal shell, and the intestine has six convolutions.

In this genus the body is elongated and often strongly keeled posteriorly. The lateral bands are always present in the Irish species, both on the mantle and body; but they may become obscured by being broken up into spots (*L. flavus*), or by the general body colour in the adult becoming black throughout. There is no caudal gland. The pulmonary opening is always situated behind a line drawn across the middle of the mantle. The skin externally is wrinkled, but the wrinkles never are so prominent as they are in the genus *Arion;* they are more pronounced, however, than in *Agriolimax* and *Amalia*, where the skin is almost smooth, especially in the latter.

There are invariably six convolutions of the intestine, sometimes with an additional cœcum. The genital opening is just behind the tentacles, and there is a solid internal shell.

There are three anatomically well-defined species of *Limax* in Ireland: one of them, viz. *Limax marginatus* (= *arborum*, Bouch), differs so much in the structure, of the reproductive organs, as well as in that of the radula, that a separate genus was proposed for it by Heynemann. Simroth (38) was the first to suggest that *Limax variegatus* (=*flavus*) should be united to this new genus *Lehmannia*, as both possess a cœcum to the intestine. But although they have this much in common, the reproductive organs in the two species are not so very similar as to make it desirable to unite them. I think that if any division of the genus *Limax* is made, *Limax marginatus* (= *arborum*) and *L. variegatus* (=*flavus*) should be placed in separate genera. The presence of a flagellum in the reproductive organs of *Limax marginatus* (= *arborum*) also shows some affinity to the genus *Agriolimax*.

Synopsis of the Irish Species of Limax.

I.—Mantle with dark spots on light ground, or uniformly dark = *L. maximus*.
II.—Mantle with light spots on darker ground = *L. flavus*.
III.—Mantle with two lateral dark bands = *L. marginatus*.

Limax maximus, L.

Limax maximus. Linné, *Syst. Nat.* 1758. Limax antiquorum, Férussac, *Hist. Moll.* 1819. Limax maximus. Jeffreys, *British Conch.* 1862.

(Plate LVI., figs. 1 and 2.)

Colour of body generally a reddish-gray, with dark lateral bands on body, continued to the posterior third of mantle, the remainder of which is spotted. Tentacles long; a faint black line runs along outer margin of foot. Intestine without a cœcum.

External characters.—I have attempted to use the markings of the mantle as a method of readily distinguishing the species of *Limax*, but there is another way, though perhaps not altogether scientific, by which *L. maximus* can easily be identified. If the mantle be touched with a pencil or other sharp instrument, the front portion curls round completely towards the source of irritation, whilst in the two other species the same portion of the mantle will be only slightly lifted. Another character by which *L. maximus* (except in very dark specimens) can be distinguished, is a faint black line, running along the external margin of the foot, which is quite absent in *L. flavus* and *L. marginatus*. Moreover, *L. maximus* is always more slender, and its tentacles are almost double the length of those of *L. marginatus*, in specimens of the same size. The largest specimen I have met with about Dublin, measured 110 mm. long, and 9 mm. broad; but I took one in May, near Lough Caragh, Co. Kerry, which in spirit still measures 85 mm. by 14 mm. As a rule, slugs shrink in alcohol to about one-half their length when alive and fully stretched out; but in this case I think the specimen can hardly have been more than 150 mm. long, which is exactly 6 inches. According to Moquin-Tandon (26), they sometimes grow to the length of 170 mm. in France.

We must not draw too rigid rules as to the limits of the specific characters of this species, for it is subject to much variation in colour, though in Ireland it is by no means the most variable of slugs, as it seems to be in Germany, according to Simroth (38).

All the specimens I have examined, whether they were of various shades of gray, or of a dark brownish colour, were anatomically identical. Roebuck, in his British Slug List (35), refers to *Limax cinereo-niger* (Wolff) as a form which is found in Ireland, and which is now separated by the best Continental authorities from *L. maximus*. He does not mention them, but Simroth (38), one of the best authorities, certainly examined the form, and found it to agree with *L. maximus*. Roebuck states, in the same Paper, that there are important differences between the species in the genital apparatus, but he does not say what they consist in. I, myself, have not had an opportunity of examining a specimen which could be referred to this species, although I have had one or two, which were quite dark above, but leaving the foot white.*

The original lateral bands are always present in quite young specimens. On the posterior third of the mantle they assume a horse-shoe shape without being continued anteriorly. Curiously enough, in the adult, the left part of this horse-shoe becomes almost always broken up into spots, whilst at the right side it generally

* I have quite recently obtained a specimen at Glengariff agreeing in every respect with the description given of *cinereo-niger*. On examination I found no difference anatomically between it and a typical *L. maximus*, except in the origin of the retractor muscle of the penis. This confirms the opinion held above that *cinereo-niger* can only be regarded as a variety of *maximus*.

persists. Thus we usually find that the mantle is uniformly spotted in the adult, except the part between the respiratory orifice and the posterior margin, where we meet with an elongated black mark, the remnant of the lateral band of the mantle. (This is well shown in Reeves' (34) figure of *L. maximus.*) The general body-colour is usually of a faint reddish-gray, turning into pure gray in spirit, whilst the dark spots and bands often become blue. The tentacles are of a light reddish-violet tint. The mucus, on the nature and colour of which rather too much importance has been placed by previous observers, is whitish, and not nearly so abundant as in *L. flavus*, and *L. marginatus.*

Anatomy (Plate LVII., fig. 25).—Both Nunneley (31) and Simroth (38) have given such detailed descriptions of the anatomy, that I need only refer again to the most salient features.

Of the six convolutions of the intestine, four are imbedded in the liver, and two hang freely in the body cavity. The hermaphrodite gland (*hg.*) is elongated and large, and is connected with the ovisperm-duct (*os.*) by means of the hermaphrodite duct (*hd.*) which takes its course through a portion of the albuminiparous gland (*ag.*). The ovisperm-duct is thick and well convoluted, and separates further down into a vas-deferens or sperm-duct (*sp.*) and an oviduct (*ov.*). The former opens into the upper end of a very long penis (*p.*), to which a strong retractor muscle (*rm.*) is attached. The lower portion of the penis unites with that of the oviduct at the genital orifice, so that there is no vestibule. The receptaculum seminis (*rec.*) opens into the lower end of the penis near the junction of the two ducts. Nunneley (31) gives a good figure and description of the reproductive organs, and although he mistook the albuminiparous gland for the testis, this is a comparatively unimportant matter.

Of course, as in all parts of the body, there are variations in the reproductive organs, and it is a matter of opinion whether, in conjunction with external differences in colour, these should be regarded as sufficient to sub-divide the species. Lessona and Pollonera (28), who have published an elaborate monograph on the Italian slugs, are evidently of that opinion, and a good deal may be said in favour of it.

I consider the shell of so little importance as a distinguishing feature that it will be enough to say that it is much larger than in any of the other species.

Reproduction.—The eggs, as far as my observation goes, are deposited in August and September, but I think another deposition takes place earlier in the year. They are very transparent, elastic and slightly yellowish in colour. Their length is 6 mm., and width 4 mm. About a month after their deposition the young appear, and from the first show two distinct lateral bands on the body, reaching to the posterior third of the mantle. The body-colour at this stage is of

a delicate reddish-yellow, the portion of the mantle above the shell being paler, owing to the transparency of the skin.

Its duration of life has generally been fixed at one year. [See Moquin-Tandon (26) and Simroth (38).] I took large specimens on the west coast in May, with reproductive organs almost fully developed, and have everywhere taken numerous half-grown ones in September; therefore I conclude that eggs are laid twice in the year. Lehmann (20) seems to be of the same opinion. It is probable that large specimens owing to the scarcity of food have less chance of surviving winter than small ones, so that comparatively few will be fully developed in the following June. In the West, where the climate is milder, large ones find food more plentifully throughout the winter, and we thus meet with many full-grown specimens by May.

Habitat.—"*L. maximus*," Miss Warren wrote to me some time ago from Co. Mayo, "is a solitary species, which may be explained by the fact that it is a great traveller." This agrees exactly with my own observation. One finds either a solitary specimen or two not far from one another, but rarely more.

There are frequent references [see Leach (19), Reeve (34), and Simroth (38)] to this slug having been found in cellars in other countries, but neither my predecessors Clarke (3) or Thompson (43), nor myself, have ever met with it in the house. I have found *L. maximus* in my own garden in Dublin, and in the country everywhere, chiefly in woods, under stones and tree trunks, and near the sea-shore, almost within high-water mark, but always locally.

Food.—Simroth (38) observes that the spirit in which specimens of *L. maximus* have been killed is never coloured green. He found that plants containing chlorophyll were always refused, whilst fungi were greedily devoured, and form the staple food of these slugs. When found in the cellar they may also live on meat or the juicy stalks of vegetables.

My experience almost agrees with that of Simroth in the above. The specimens which I kept in captivity only once gnawed at the green leaf of a Campanula after having received no other food for a week.

This species, like many others, occasionally exhibits a strong tendency towards cannibalism. It appeared to me that, especially where one specimen became rather sickly, the others would seize upon it and devour it.

Quite recently Gain (10) published some very interesting observations on the food of slugs. He says—"*L. maximus* is a very dainty feeder, preferring fungi to all other foods, and it seems to be harmless in the garden." Kew (17) writes on the same subject, "This species feeds freely on bread, and it also ate Russula emetica, but ripe berries of *Solanum dulcamara* were refused."

General Distribution.—Great Britain, throughout Continental Europe and

Asia Minor; also the islands of Sicily, Corsica, Sardinia, Azores, Madeira, and New Zealand (introduced), and East Coast of North America (introduced).

Limax flavus, L.

Limax flavus. Linné, *Syst. Nat.*, 1758. Limax variegatus—Draparnaud, *Table Moll.*, 1801. Limax flavus—Jeffreys' *Brit. Conch.*, 1862.

(Plate LVI., fig. 3.)

Colour of body, lemon or orange-yellow spotted with gray, the spots being arranged in bands. Tentacles bluish. The intestine has a cœcum, but there is no flagellum.

Synonymy.—The name "*variegatus*" of Draparnaud (5), adopted by Moquin-Tandon (26), Simroth (32), and others, is not correct by the law of priority. Lessona and Pollonera (21) have pointed out that we cannot remain in doubt about the identity of Linné's species with that of Draparnaud, as the former refers to Lister's (22) figure, which is unmistakable.

External Characters.—The species is very constant in its external characters. This slug appears to be of a uniformly lemon-yellow colour; on closer inspection, however, we find that the yellow is obscured to such an extent by a delicate gray, especially on the mantle, that it seems as if there were yellow spots on a gray ground. Towards the sides of the body and mantle the colour becomes more of an orange. Specimens taken in my own cellar were more vividly coloured; they were always of a deep orange-yellow. But the yellow colour in this slug is entirely due to an abundant mucus, covering the body at all times. When it is wiped off, the true body-colour is revealed, which is a dull flesh tint. Although the secretion from the dermal glands of the back is so intensely yellow, the ordinary mucus of the foot is colourless and very abundant.

The tentacles present a very striking character, being of a delicate blue colour. They are shorter and thicker than in either of the two other species of *Limax*. But the wrinkles are, perhaps, the most characteristic feature in this slug. They are closely set, and have been likened by Simroth (38) to strings of pearls (perlschnurartig).

The largest specimen I have seen was 80 mm. long, by 10 mm. broad; so that it is considerably smaller than the preceding species, but rather broader for its size. Altogether, it is more rounded than *L. maximus*, and there is only a faint indication of a keel at the tail end of the body.

Only once have I seen a specimen which exhibited a trace of a band on one side of the mantle, but never on the body.

Anatomy (Plate LVII., fig. 26).—There are the same six convolutions of the intestine as in the preceding species, but *L. flavus* is distinguished from it, and resembles the next species, in having a blind process or cœcum attached to the end portion of the intestine. This remarkable feature induced Simroth (38) to unite *L. variegatus* (= *flavus*) and *L. arborum* (= *marginatus*) into one sub-genus. This author informs us that Selenka had discovered the presence of the cœcum; however, Nunneley (31) described it thirty years before him. The latter mentions that this cœcum consists of but little more than delicate cellular tissue, that it is always collapsed, and that the contents of the intestine do not pass down it.

The hermaphrodite gland (*hg.*) is not so elongated as in *L. maximus*, and is of a light yellow colour, but the shape of the gland naturally varies very much, and is therefore not of importance in the diagnosis of the species. The ovispermduct (*os.*) seems rather shorter than in *L. maximus;* and the receptaculum seminis (*rec.*) is larger, and opens into the lower portion of the oviduct (*ov.*)

Reproduction.—The eggs of this species are at once recognized as distinct from those of *L. maximus.* They are provided with a minute sharp point at each end of the longer diameter. Those I examined were 7 mm. long., and 5 mm. broad; but, according to Simroth (38), they vary considerably in size, he having found some measuring 11 mm. long. They are somewhat yellowish in tint, and rather firmer in consistency than those of *L. maximus.* I found them at the end of November in an old tree trunk near Dublin, and the young slugs emerged a few days later. These young ones are much darker than the adults. They are of a somewhat greenish colour, and many of them had a very distinct light stripe running down the back, the sides being darker; otherwise they resemble the adults so much that there is no difficulty in recognizing the species at once.

In the cellars, where this species is common, I have obtained adults up to November, but in December not a single adult was seen. They must have died off, young and half-grown specimens being numerous. The fact of there being half-grown ones in December also proves that a deposition of ova takes place in the early months of summer.

Habitat.—*L. flavus* lives chiefly in cellars and kitchens, but it is by no means scarce in the country. I have often taken it in woods under the bark of old trees, along with *L. maximus*—always a number of them together. In Germany it seems to be almost exclusively confined to cellars.

Taylor and Roebuck (42) report its occurrence at Waterford, whilst I have taken it everywhere in the county Dublin; and Thompson (43) records its presence in the North. I have also received specimens from Mr. Barrett-Hamilton from Wexford.

Food.—Clarke (3) states that he kept specimens in confinement on bread, which they eat voraciously. I tried them with campanula leaves, but they would not touch them. Gain (10) found that they eat the stalks of cabbage and lettuce, raw and cooked potatoes, turnips and fruits, but that their favourite food is cream. Of foliage they took only the holly (*Ilex aquifolium*) at first, but he induced them later on to take leaves of the bean plant, bryony (*Bryonia divisa*), *Campanula latifolia*, and others. I have once found them feeding on a large fungus, and as they never colour spirit green, I have no doubt that Simroth (38) is right in concluding that their natural food consists in non-chlorophyllaceous substances.

General Distribution.—Great Britain; throughout continental Europe and Asia Minor; also the islands of Sicily, Sardinia, Madeira, the Azores, and Balearic Isles. It occurs also, but has probably been introduced, on the east coast of North America and Brazil, as well as in Australia and New Zealand.

Limax marginatus, Müller.

Limax marginatus, Müller, *Hist. Verm.*, 1774. Limax arborum, Bouchard-Chantereaux, 1838, *Cat. Moll. Terr. et Fluv.*, *Pas-de-Calais.* Limax arborum, Jeffreys, *Brit. Conch.*, 1862.

(Plate LVI., fig. 4.)

Body gelatinous, only slightly keeled towards tail. Colour, generally a reddish gray; dark lateral bands on body, continued to the front of mantle. Tentacles short. A cœcum in intestine, and a flagellum attached to penis.

Synonymy.—Jeffreys (16), in his text-book, seems to take it for granted that the species described under the above name by Müller (28) is identical with Draparnaud's (5) *marginatus*, although Draparnaud himself did not feel certain, on account of its different habits. What Draparnaud described was either the *Amalia carinata* (Leach) or a closely allied species; for, whilst Müller distinctly mentioned that his species inhabits the beech, Draparnaud's is a ground slug, and never ascends trees.

External Characters.—I have already mentioned that the lateral lyre-shaped bands on the mantle are a most typical character. In very dark specimens these bands may almost disappear; but I have never seen one in which they could not be recognized. The bands alone are sufficient to distinguish this slug from *L. maximus* and *L. flavus.* Moreover, it is distinguished from all other slugs by its gelatinous appearance, and the slightest touch will cause it to give off a most abundant watery mucus. It never grows to the size of *L. maximus*, with which, by the uninitiated, it might be confounded. The largest specimen I have seen measured 80 mm.

The general body-colour is a reddish or sometimes a bluish gray, which may be more or less obscured by darker bands or spots. In almost all cases a lighter stripe is left, which runs along the middle of the back. The posterior third of the body is carinated, but the keel is not nearly so marked as in *L. maximus*. The ground-colour of the mantle is as a rule lighter than that of the body. The middle portion is gray, and bordered on each side by a strip of light ground colour. The dark lateral bands almost surround the whole, although they do not quite meet in front or behind. The head is reddish gray, but it is also subject to slight variation in colour. The tentacles, as has been remarked before, are about half as long as those of an equal-sized specimen of *L. maximus* (fig. 2), and are somewhat similar in tint.

Anatomy (Plate LVII., fig. 27).—The interior of the body-cavity, especially posteriorly, is darkly pigmented. The intestinal convolutions are similar in number and shape to those of the preceding species, and there is also a cœcum. The hermaphrodite gland (*hg.*) is smaller than in the two other species of *Limax*, generally dark in colour, and often divided into two portions. The ovisperm-duct (*os.*) is thick and short. The sperm-duct (*sp.*) and penis (*p.*) very short, the latter being distinguished by the presence of a flagellum (*fl.*) which may be looked upon as an accessory gland. The receptaculum seminis (*rec.*) opens, as in *L. maximus*, into the lower portion of the penis.

Reproduction.—I kept a number of specimens of this species in captivity from September until December. Eggs were deposited from the end of September till the middle of October, on an average about twenty in a cluster. The sizes varied somewhat, but they were mostly $5\frac{1}{2}$ mm. long by 4 mm. broad, and were extremely like those of *L. maximus*—very transparent and elastic. The young made their appearance exactly four weeks after the deposition of the eggs, and were of a reddish-violet colour throughout. Even at this stage, from the very first day of their birth, they are easily distinguished from *L. maximus*. The tentacles are about 2 mm. long in the latter, while in *L. marginatus* they are only 1 mm. in length. The young *L. marginatus* is born with the lateral bands fully developed, reaching right to the front, whilst in *L. maximus*, as we have seen, they stop short at the posterior third of the mantle. The bands on the body of the young, as Simroth (38) has pointed out, are not equivalent to those in *L. maximus*. In fact, they are not the real lateral bands (Stammbinde), but the inner bands, which appear much later in *L. maximus*. As I found a large number of specimens in September, measuring from 30 to 40 mm., we may conclude that in this species also there must be a deposition of ova at least twice in the year. Simroth (32) believes that this species lives through several years, but I venture to think that more evidence is needed to support this opinion.

Habitat.—*Limax marginatus* has a wide range in this country. Both

Thompson (43) and Clarke (3) found it common in the North, on the stems of trees after rain. Taylor and Roebuck (42) report its occurrence from Kerry, Waterford, and other counties. Forbes and Hanley (9) state that they found it plentifully on bare rocks at an elevation of above 1500 feet near Connor Cliffs, above Dingle, in Kerry. It is a very common form around Dublin, but it is peculiar to the open country, and not found in gardens. It is seen both on the trunks of trees and among rocks, and under stones. The Rev. A. H. Delap sent me specimens from the Skelligs Rock agreeing in every respect with the mainland forms. This is a large bare rock, about ten miles from the coast of Kerry. Neither bush nor tree grows on it, and in westerly winds it is enveloped in a mist of spray, the waves beating over the greater part of it. From the Aran Islands in Galway Bay, which are quite bare and rocky, I have also received specimens, and, no doubt, this species occurs on all the islands along the west coast.

Food.—According to Lehmann (20) this slug is both carnivorous and herbivorous, but Simroth's (38) experience goes to show that it only touches animal food when driven by stress of hunger. He also states that the spirit is coloured green, not by the chlorophyll of leaves, but by that contained in lichens, and that the latter constitute the real food of *L. marginatus.*

This is very much my own experience. My captive specimens refused to touch green leaves or fish, and after four weeks they died from starvation. Although these observations are of some importance in establishing the nature of food which slugs live on, further experiments are needed to decide beyond doubt what the natural food of *L. marginatus* consists in. Gain (10) states that the specimens which he kept in captivity would not touch mosses, lichens, or fungi. This may be due to an unsuitable kind of lichen having been chosen, or else that the slugs were, for some reason or other, unwilling to feed at all.

General Distribution.—Great Britain, and the greater part of continental Europe; also the islands of Iceland and Sicily.

GENUS II.—**Agriolimax.** (Malm, 1868.)

Animal keeled only posteriorly. Mantle concentrically striated, the centre of striæ being somewhat to the right of median line. There are no bands, and if spots are present they are irregularly scattered over the body. Pulmonary opening behind middle of mantle, and genital pore near tentacles. The intestine has four convolutions, and there is a solid internal shell; no caudal gland.

This genus includes some species which used to form part of the genus *Limax*, and in most modern text-books they are still retained under that denomination. Of course it is much better not to give up an old well-known name too readily; but a large number of species have been found in recent years in various parts of

Europe which may, with our two species, *A. agrestis* and *A. laevis*, be united into one group, differing in many important features from the genus *Limax*. The name *Agriolimax* has been adopted by such authorities as Simroth (38), Lessona and Pollonera (21), and Malm (25), although it is not by all of them used in the same sense. I have adopted Simroth's definition of the genus. The differences in the intestine alone are sufficient to separate the two forms *A. agrestis* and *A. laevis* from the Limaces, but there are additional and not less important differences. *Agriolimax* has only four convolutions of the intestine instead of six, and these four are altogether different in position from those in *Limax*. In the last genus the left lobe of the liver formed the apex of the intestinal sack ; in *Agriolimax* it is the right. The reproductive organs do not show any very important difference in the two genera, with the exception, perhaps, of the retractor muscle of the penis. The chief objection to the more general recognition of this genus among Malacologists seems to be in the difficulty of fixing a constant character by which *Agriolimax* may be distinguished from *Limax* externally. Simroth (38), however, has shown, in his excellent monograph, that the species of *Agriolimax* never at any period of their lives possess bands. If in some varieties the irregular concentrations of dark pigment here and there appear to produce a kind of lateral band, we must not be led astray by appearances. In the genus *Limax*, on the other hand, lateral bands are always present, at any rate during youth. They may in later stages unite or break up into irregular spots, but in almost all cases their presence can be easily demonstrated.

The food in *Agriolimax* is different from that of the Limaces. As we have seen the natural diet of the latter is probably fungi and lichens, but *Agriolimax* lives on the higher phanerogamic plants. It is a most destructive pest in the field and garden, whilst the Limaces are comparatively harmless; indeed, they might even be called useful slugs.

SYNOPSIS OF THE IRISH SPECIES OF AGRIOLIMAX.

I.—Mantle about one-third the length of body. Mucus milky = *A. agrestis.*
II.—Mantle about one-half the length of body. Mucus colourless = *A. laevis.*

Agriolimax agrestis, L.

Limax agrestis. Linné, *Syst. Nat.* 1758. Limax agrestis, Jeffreys, *Brit. Conch.* 1862. Agriolimax agrestis, Malm, *Limacina Scandin.* 1868.

(Plate LVI., figs. 5 and 6).

Body-colour generally of a yellowish-white, irregularly spotted with gray, sometimes of a uniform gray or brown ; mantle about one-third the length of body. Slime milky. A cœcum in intestine.

External Characters.—As a rule *Agriolimax agrestis* may be distinguished from *A. laevis* by the colour alone. The former is almost always of a dirty yellowish-white colour (fig. 5), either with or without diffuse patches of a darker pigment. The latter may altogether obscure the original body-colour, and produce a bluish slate-coloured slug (fig. 6). I have had two specimens from the Aran Islands, county Galway, which resembled *A. laevis* in so far as they were of a dark chocolate colour, but the milky slime, the short mantle, and the more pronounced keel were sufficient to pronounce them as mere varieties of *A. agrestis*. Anatomically they differed in no way from the usual form.

A. agrestis grows to a much greater size than *A. laevis*, the largest specimen measuring 40 mm. by 5 mm. According to Moquin-Tandon (26) it reaches the length of 60 mm. in France.

In a fully extended specimen the mantle occupies exactly a third of the total length of the body, which is somewhat compressed posteriorly, and there is a well-marked keel reaching from the posterior third to the end of the body. The head and tentacles are faintly violet-coloured, but vary according to the general body tint.

Quite fifty per cent. of the varieties I picked up during the summer in the country near Dublin were of a uniform yellowish-white, the space between the wrinkles being marked by a very light gray, so that the shape of each body-wrinkle was well seen. Once I obtained a perfectly white albino specimen under a heap of hay at Raheny. In November 60 per cent. of the *A. agrestis* in my garden were of a yellowish-white colour, faintly speckled with gray. On the other hand, of those obtained at the same time from the Aran Islands, 80 per cent. had the ground colour reddish-yellow, but they were uniformly mottled with dark gray, two specimens being almost black. The mucus in this slug is very abundant, and of a milky colour.

Anatomy. (Plate LVII., fig. 28).—There are only four convolutions in the intestine of this species and the next, as has been shown by Nunneley (31), and more recently by Simroth (38). But Nunneley did not notice the small cœcum near the terminal convolution of the intestine. Simroth pointed out that it is not homologous with that in *Limax*, being differently situated. The hermaphrodite gland (*hg.*) is elongated, and generally the acini composing it are split up like a bunch of grapes. The hermaphrodite duct (*hd.*) is almost always straight, *i. e.* not convoluted like that in *Limax*. Close to the genital pore, the ovisperm-duct (*os.*) divides into oviduct (*ov.*) and sperm-duct (*sp.*). The latter is short and opens into the very large penis (*p.*). The receptaculum seminis (*rec.*) is placed at the junction of the penis and oviduct. Near the opening of the sperm-duct into the penis, an accessory gland, the flagellum (*fl.*), opens into it also, and I found this to vary somewhat in the different specimens I examined.

A Paper dealing with the anatomy and histology of the alimentary canal and the nervous system has recently been published by Dr. Hanitsch (12).

Reproduction.—The eggs are globular and perfectly transparent, measuring 2 mm. in diameter. The specimens I kept in captivity produced only about 30 eggs each, but according to some authorities the same slug may deposit a large number during a short period. Thus, Moquin-Tandon (26) mentions that one specimen has, at different times, produced as many as 300 or even 350 eggs; and, according to the same authority, Leach is stated to have observed two slugs deposit 776 eggs. Although, no doubt, this slug is extremely prolific, I venture to think that further experiments are needed to confirm these observations. The young do not seem to me to present any appreciable differences from the adults.

I have taken specimens with fully developed reproductive organs from March to December. In the latter month and January the large specimens seem to die off, but it is difficult to determine their length of life. Simroth (38) believes that they live only one year.

Habitat.—*Agriolimax agrestis* is to be met with everywhere. It is the commonest, and probably the most destructive of all slugs. The damage done by it in the garden as well as in the field is enormous. It begins its ravages in the evening soon after sunset, and feeds the whole night through until the morning, when it retires for the day into worm-burrows or underneath stones and clods of earth. It seems to be little affected by weather or climate, being equally common on the islands of the west coast, on the mainland, and on the continent of Europe.

This slug is very active, and when touched, it glides through the fingers, leaving a mass of milky slime behind, and rapidly crawls away. As I have mentioned, I have seen the very dark variety only from the Aran Islands. The dark slate-coloured variety, described by Clarke (3), only once occurred to me along the high road to Whitechurch, near Dublin, and there were plenty of them on the spot.

Food.—*Agriolimax agrestis* is very voracious and omnivorous, but I think green food is preferred. In captivity they seemed to relish anything they were offered, and in this respect they are very different from most other slugs. In the garden I found them chiefly injurious to peas. They will eat the young shoots and the flowers, and even devour the pods. I doubt whether they do much damage underground to bulbs, which are chiefly preyed upon by *Amalia carinata.*

General Distribution.—Great Britain, and throughout continental Europe, Asia Minor, Persia, Siberia (?), Japan, Iceland, Greenland, the Azores, Madeira, Marocco. It has probably been introduced on the east coast of N. America, in Brazil, South Africa, and New Zealand.

Agriolimax laevis, Müller.

Limax laevis. Müller, *Hist. Verm.*, 1774. Limax brunneus. Draparnaud, *Table Moll.*, 1801. Agriolimax laevis. Lessona and Pollonera, *Monogr. Limac. ital.* 1882.

(Plate LVI., fig. 7.)

Body of a purplish brown colour. Mantle about one-half the length of body. Slime watery. Intestine without a cœcum.

External Characters.—This slug has not been recorded before from Ireland. It was discovered by Mr. Rathborne in Lord Massy's estate at Killakee, near Dublin, and brought to me for identification. I shortly after found two additional specimens in the same place, *i.e.* along the banks of an old fish pond. Unfortunately none of the specimens were full grown, but I at once distinguished it, as I had expected to find it before, it having a very wide distribution, ranging all over Europe and America.

The best description which I have seen of this slug is that by Heynemann (14). According to him *A. laevis* differs chiefly from the closely allied *A. agrestis* by the size of the mantle, which is almost one-half the total length. The back is only very slightly keeled towards the end of the body, which is of a dark purplish brown colour throughout. Simroth states that younger specimens are of a dark gray, but those I found which only measured 3 mm. and 10 mm. respectively were precisely the same in colour as the largest which measured 15 mm. Its maximum length, according to Heynemann, never exceeds 20 mm. (about three-quarters of an inch), so that it is the smallest of our native slugs. The neck can be stretched out very considerably. The mucus is perfectly clear and transparent, by which the species can perhaps most easily be recognized.

The shell, especially in younger specimens, is often visible through the mantle, and its outlines are indicated by a golden yellowish colour.

Anatomy (Plate LVII., fig. 29).—All the specimens I found being immature, the reproductive organs were not fully developed. The intestine is similar to that in the last species, but the cœcum is entirely wanting. The largest specimen, measuring 15 mm., which I dissected, had only the female reproductive organs developed. This agrees with Simroth's (38) observations, who found that the female portion of the generative organs was generally developed before the male portion. The hermaphrodite gland (*hg.*) is dark, the rest of the reproductive organ being much the same as in *A. agrestis*, with the exception perhaps of the penis, which, according to Simroth is hammer-shaped, the flagellum being of a very different shape from that in *A. agrestis* (32 Plate ix., fig. 17).

Reproduction.—I have not observed the eggs of this slug. Simroth (38) tells us that they are about the same size as those of *A. agrestis*, measuring between 1·25 mm. and 2 mm. in diameter. Moquin-Tandon (26) states that in *Limax brunneus* Drap (=*A. laevis*) the eggs are $1\frac{1}{4}$ mm. long and 1 mm. broad, and that the number at each deposition varies from twelve to eighteen. Simroth found young at all seasons, but does not give an opinion as to the limits of age in this species, and my own observations are so limited that I cannot venture to express an opinion.

Habitat and Food.—In Ireland this species seems to be very local, and it certainly never occurred to me in company with *A. agrestis.* In Germany it is found along with *A. agrestis* in the garden and field, but everywhere it appears to prefer damp situations, being commonest near banks of rivers or in ditches.

Mr. Burbidge, of the Trinity College Botanic Gardens in Dublin, mentioned to me quite recently that a little black slug had appeared in his orchid houses. I managed to secure a specimen, and found it to be an *Agriolimax laevis*, and I ascertained that the sphagnum moss so extensively used in the cultivation of orchids was brought down to Dublin from the neighbourhood of Killakee, the only locality where I have met with this species.* It seems to thrive in the warm orchid house, and manages to do a good deal of damage to the delicate flowers. I have not been able to ascertain what food it lives on in its original home.

General Distribution.—Great Britain, and throughout continental Europe; Siberia, and throughout North America and Brazil.

GENUS III.—**Amalia** (Moquin-Tandon, 1855.)

Animal generally sharply keeled along the whole of body behind mantle. Mantle, which is shagreened or granulated, has a horse-shoe shaped groove. Body without bands. Pulmonary opening behind middle of mantle. Genital opening near base of tentacles. Intestine has four convolutions, and there are accessory glands in connexion with oviduct or vestibule. There is a solid internal shell, but no caudal gland.

This genus, like that of *Agriolimax*, has formerly been united with the genus *Limax*, and the various species of *Amalia* are found under the latter genus in such text books as Jeffreys (16) and Forbes and Hanley (9). In recent years the structure of slugs and their habits having become better understood, mostly owing to the labours of Simroth and of Lessona and Pollonera, the grouping under one genus of a number of miscellaneous forms has been discontinued.

Externally the Irish species are characterized by a sharp ridge or keel running along the whole of the back. In some of the Continental forms this keel does not seem to form such a prominent feature. A character which is applicable

* Since writing the above, I found this slug also in Connemara, county Galway, and at Killarney, county Kerry.

to all the species and by which the genus is most readily distinguished from others, is the deep horse-shoe shaped groove on the mantle. The mantle, moreover, is different from that in the two preceding genera in being granulated.

As regards the internal organization, the genus is more closely allied to *Agriolimax* than to *Limax*, but still there are many very important differences. There are four convolutions to the intestine in both genera, but *Amalia* has accessory glands in connexion with the vestibule or oviduct, which are absent in *Agriolimax*. On the other hand, the penis in *Amalia* has no accessory gland or flagellum. The sperm is transmitted by means of a spermatophore in *Amalia*, and by a soft mucous capsule (Schleimpatrone) in the other. *Agriolimax* is quick in its movements, has a delicate skin and abundant liquid mucus, whilst *Amalia* is slow, with thicker skin and often with tough viscid mucus.

SYNOPSIS OF THE IRISH SPECIES OF AMALIA.

I.—Colour generally brown, foot yellowish, and mucus viscid = *A. carinata.*
II.—Colour generally black, foot white, and mucus watery = *A. gagates.*

Amalia carinata, Leach.

Limax carinatus. Leach, *Synops. Moll. Brit.*, 1820. Limax marginatus. Jeffreys, *Brit. Conch.*, 1862 (not Müller.)

(Plate LVI., fig. 8.)

Colour of body generally brown. Groove on mantle almost always filled with dark pigment. Skin thick, and interstices between wrinkles filled with black pigment, and slime viscid. Keel of a lighter colour than rest of body. Foot yellowish. Receptaculum seminis very large and elongated.

Synonymy.—The name *Limax marginatus* applied to this slug by Jeffreys (16) has already been disposed of, having evidently been intended by Müller (28) for quite a different species. The name *L. marginatus* has been kept up by Taylor and Roebuck (42) in their Irish list, and in the *Conchological Journal* (41), but it has been discontinued for the British form by Continental authors, such as Simroth (38) and Lessona and Pollonera (21). I think there is no doubt that the Irish form is the one described by Leach (19) as *Limax carinatus.* I was not sure whether it was the same as the Continental, at least the German form, so I submitted specimens of several varieties to Dr. Simroth, who pronounced them to be *Amalia carinata*, Risso. He tells me they differ but little from the German specimens, hardly sufficiently to attach to them a distinct varietal name. The proofs of Leach's work (19) were in circulation in 1820, so that his name should be attached in preference to that of Risso.

External Characters.—*A. carinata* is at once distinguished from all the preceding species by the prominent ridge or keel running from the posterior margin of the mantle to the end of the body. A less conspicuous feature, by which this and the next species may be distinguished from all others, is the horse-shoe shaped groove on the mantle. In *A. carinata* this groove is almost always filled with a black pigment, so as to render it more readily visible than in the next species. Some authors have thought it advisable to create a separate name for specimens in which the black marking meets in front to form a complete horse-shoe. However, I have examined a large number of specimens from gardens in Dublin where it is, after *Agriolimax agrestis*, the commonest slug, and I found that in fully 20 per cent. the horse-shoe marking is complete, *i.e.* unites in front. In some specimens there was only a faint indication of any marking at all; in fact, it is a feature which is not by any means constant. I noticed also that in those 20 per cent. in which the black pigment extends all round the groove, the general body-colour is darker than in the others.

The body-colour in this species varies from yellowish brown to dark brown, the sides getting lighter towards the foot. The inter-space between the wrinkles is generally marked by darker pigment, and the mantle is granulated. The head and tentacles are of a bluish colour, sometimes purple, and the keel is almost always lighter than the body-colour on each side of it.

The largest specimen taken measured 65 mm. long, by 10 mm. broad. Moquin-Tandon's (26) *Limax marginatus*, which is probably this species, never exceeds 60 mm. in length in France.

Anatomy (Plate LVII., fig. 30).—There are the four convolutions of the intestine as in *Agriolimax*, but without a cœcum. The upper portion of the reproductive organs are like those of *Agriolimax*, but in the lower parts, important differences appear. The receptaculum seminis (*rec.*) is very large, equalling the free oviduct (*ov.*) in length. Its lower part is wide, but it becomes attenuated in its upper portion. What appears to be the penis is in reality the portion of the sperm-duct in which the spermatophore is formed (*pat.*); the lower portion only can be looked upon as a penis (*p.*). Both penis and oviduct, as well as the receptaculum, open into a short vestibule or atrium (*lv.*) which, according to Simroth (38), is everted during copulation. A number of large accessory glands (*ac.*) also open into the vestibule by means of delicate ducts.

Reproduction.—The fact that hardly any of the text-books referred to, give a description of the eggs of this species shows that they have rarely been observed. Although I kept a large number of specimens in captivity from the middle of September to the end of the year, none of them deposited eggs. Simroth (38) is the only author who refers to the ova of *Amalia marginata*, which is either the same or a closely allied species to ours. He states having observed them at the end

of March, and that they measure 6 mm. by 5 mm. They are, therefore, about the size of those of *L. maximus*, and very much larger than one would expect. I have met with a good many specimens of the slug, about 15–20 mm. long in July, so that the deposition of eggs in Ireland probably takes place in April or May. The young ones do not differ to any appreciable degree from the adults. I saw no half-grown or young specimens during winter, so that at any rate the reproduction of this form seems to differ from that of most other slugs, and in all probability it lives for more than one year.

Habitat.—Simroth gives limestone rubble (kalkgeröll) in mountainous districts as the abode of the *A. marginata.* The habitat of our *A. carinata* is totally different. It is one of the commonest garden slugs in Dublin. It is very gregarious, and one often finds a number of them close together in worm-burrows, or at the root of delicate plants. They are, like all slugs, fond of stiff clay soil, which keeps the moisture so much longer than sandy soil, and which, owing to the numerous worm-burrows, gives them better shelter. They spend the day underground, and come out at night in damp weather, but they often drag bits of stalks underground to feed on at their leisure. In the open country I have met with them everywhere, but only locally. They are widely distributed. Miss Warren tells me that this species is rare in Sligo, whilst *A. gagates* is common, but I have received a large number of *A. carinata* (rather dark ones) from the Aran Islands, county Galway, and it probably occurs everywhere in the West. These did not differ anatomically from our Eastern forms. It seems surprising that Clarke (3), who was such an authority on slugs, did not meet with this species in the North of Ireland, and only records it from Dublin, whilst Thompson (43) gives Monivea and Clifden in county Galway, and Cork, as the localities where it occurred to him.

Food.—Simroth (38) believes that the German species of *Amalia* are carnivorous. Although the Irish *A. carinata* is carnivorous at certain times, it is generally a most determined vegetable feeder, and, I believe, runs *Agriolimax agrestis* very close in being the most voracious and destructive of slugs.

As I mentioned before, I have had specimens in captivity for several months, and I have had good opportunities for observing its habits in the garden. I find that it is especially fond of leaf stalks and bulbs, but it greedily devours green leaves. The bulbs and stalks seem to suit them better when they are stale and beginning to decay. Of the thirty or forty which I kept in a large tin box filled with earth, and always supplied with leaves, bulbs, &c., about a dozen were eaten by their companions, only the shells being left. Observing them very closely, I noticed that only weak specimens, which seemed either old or seized by illness, were devoured.

The more vigorous ones always spent the day underground, burying themselves several inches deep. In the garden I noticed that many bulbs in heavy soil

entirely disappear. This would be commonly attributed to the nature of the soil, but it is really due to the depredations of *A. carinata*. I find that in sandy soil bulbs are less liable to be attacked by this species. Gain (10) states that *A. marginata* (= *carinata*) took most of the different kinds of foods offered. I hope this writer will publish a more detailed account of the nature of the food offered than what has hitherto appeared.

General Distribution.—Great Britain, Germany, Switzerland, France, Austro-Hungary, Greece, Italy, Spain, and Portugal.

Amalia gagates, Drap.

Limax gagates, Draparnaud, *Table Moll.*, 1801. Amalia gagates, Heynemann, *Mal. Blätter*, 1861. Limax gagates, Jeffreys' *Brit. Conch.*, 1862.

(Plate LVI., fig. 9.)

Colour generally dark lead or light drab brown. Keel of nearly the same colour as the rest of body. Interspaces between wrinkles and groove on mantle without black pigment; foot white, and slime watery. Receptaculum short and round.

External Characters.—As I have stated in the synopsis, this slug is distinguished from *A. carinata* by its colour, which is black, or, more correctly, dark lead. There is also a brown variety, but even then the two species are readily distinguishable. In *A. carinata* the brown is always richer, being either a deep rich brown or a bright yellow-brown, while in the variety of *A. gagates* it is always a light drab-brown. Besides, the foot is always pure white, the skin delicate, and the mucus watery. In *A. carinata* the foot is yellowish, the skin is thick, and the mucus tough and sticky. Both species may be distinguished merely by the touch. Whilst *A. carinata* feels like a sticky lump of fat, *A. gagates*, owing to its more watery mucus, glides readily through the fingers.

In this species the horse-shoe shaped groove on the mantle is well marked, but there being no black pigment, it is not so apparent as in the preceding one.

The mantle in *A. gagates* is almost of the same size as the body, whilst in *A. carinata* it is only about three-fourths of the length. The keel in *A. gagates* is much sharper than in *A. carinata*, and the interspaces between the body-wrinkles have no black pigment, which in *A. carinata* gives it the speckled appearance.

The largest specimen I have seen measured 50 mm. by 6 mm., showing that it is altogether smaller and more slender than the other *Amalia*.

Anatomy (Plate LVII., fig. 31).—Full-grown specimens measure about 30 mm. in

spirit. The various parts of the reproductive organs differ from those in *A. carinata*, chiefly in being much shorter. The sperm-duct (*sp.*), the "Patronenstrecke" (*pat.*), and the receptaculum (*rec.*) are all shorter, in comparison with the same organs in the preceding species. The receptaculum seminis (*rec.*) exhibits, perhaps, the most striking difference, being more rounded, with a short stalk. There is generally one accessory gland (*ac.*) opening into the vestibule, but sometimes there are more. I have noticed in a brown specimen as many as four, whilst in another from the same locality there was only one.

Reproduction.—The smallest specimens I have seen measured about 20 mm., and did not differ very materially in colour from the adults. A specimen kept in captivity deposited eight eggs at the end of August. They were very delicate and thin-shelled, adhering together by a glutinous mucus. They were slightly oval in shape, and measured only 2 mm. long by $1\frac{1}{2}$ mm. broad. It is surprising that there should be such a very great discrepancy between the size of the eggs in the two species of *Amalia*.

Habitat.—This species is one of the rarest of slugs; and I never found it but in the open country, and only at all abundant in one spot, at Raheny, near Dublin, in a field under heaps of decayed weeds. In the same place I obtained an occasional specimen of the drab-coloured variety among the others. Later on I found a few specimens at Kilruddery and Whitechurch, both near Dublin. I received two specimens from Miss Warren, who found them in her garden at Ballina, in Sligo; and a dark one from the Aran Islands, along with a number of *A. carinata*. Clarke (3), who first discovered this species in Ireland, states that in the Queen's County, at La Bergerie, the brown variety is much commoner than the black. He has taken the slug also in the counties of Galway and Mayo, it being very abundant in the latter.*

Food.—Gain (10) states that this species took 83 per cent. of the different kinds of food which were offered. I have not myself observed what it lived on, but it seems probable that its chief natural diet consists in decaying plants.

General Distribution.—Great Britain, France, Italy, Spain, Portugal, Sicily, Sardinia, the Balearic Isles, Egypt, Algiers, Morocco, the Azores, Madeira, St. Helena, Ascension, South Africa (?), California (?), Bermuda, and, probably introduced, in Brazil.

GENUS IV.—**Arion** (Férussac, 1819).

Body, nearly cylindrical, strongly wrinkled. Mantle, shagreened or granulate. There is a caudal gland. Internal shell, not solid, but composed of a soft mass of granules. Pulmonary opening in front of middle of mantle, and genital pore

* I have since taken it at Queenstown, county Cork.

situated close to it. There never is a well-marked keel except in young specimens. The intestine has four convolutions.

The most apparent characteristic by which this genus may be distinguished from the preceding ones are the presence of a caudal gland, and the fact of the respiratory opening being situated in front of the middle of the mantle.

The caudal gland is easily visible externally (Plate LVI., fig. 10). Its opening is situated at the very end of the body, and is triangular in shape; the base of the triangle being directed towards the head.

Another, perhaps, less noticeable feature is that of the reproductive pore, which lies quite close to the respiratory opening, whilst we have seen that in the other genera it is situated near the tentacles.

The mantle, or shield, in *Arion* is granulated as in the genus *Amalia.*

All the species of *Arion* are altogether broader in shape than any of the slugs hitherto considered.

There never is, in *Arion*, a well-marked keel, and though we may, as in young *Arion hortensis* and *A. bourguignati*, have slight indications of one, it is nothing like what obtains in *Limax*, *Agriolimax*, or *Amalia.* The wrinkles are generally more prominent in *Arion* than in the other genera.

As regards the internal structure of the genus *Arion*, I may mention in the first place that there is no solid shell, but a soft mass of calcareous granules, which, in some of the smaller species, may be somewhat firmer than in the larger ones. Simroth (38) has pointed out, that whilst *Limax*, *Agriolimax*, and *Amalia* utilize their male end-organs during copulation, in *Arion* the female end-portions of the reproductive organs are used as penes. What is generally looked upon as the penis in *Arion* is no such thing, there being no retractor muscle to it. The enlarged end portion of the sperm-duct is used for the preparation of the spermatophore (sperm-case), and Simroth (38) has applied to it the term "Patronenstrecke" (cartridge-portion).

There are four convolutions in the intestine, the first being the largest.

SYNOPSIS OF THE IRISH SPECIES OF ARION.*

A.—Margin of foot with transverse striae = *A. ater*, *A. subfuscus.*

I.—Wrinkles keeled and elongated = *A. ater.*

II.—Wrinkles flat and short = *A. subfuscus.*

* It is very difficult to give good external distinctions for the species of *Arion*, but the above will be found fairly practical, if it be kept in mind that wrinkles are a variable feature and that slugs must be compared under similar atmospheric conditions.

B.—Margin of foot without transverse striae = *A. hortensis*, *A. bourguignati*, *A. intermedius*.

I.—Foot coloured = *A. hortensis*, *A. intermedius*.

a. Wrinkles flat = *A. hortensis*.
b. Wrinkles with conical spikes = *A. intermedius*.

II.—Foot white = *A. bourguignati*.

Arion ater, L.

Limax ater and L. rufus, Linné, *Syst. Nat.* 1758. Arion empiricorum, Férussac, *Hist. Moll.* 1819. Arion ater, Jeffreys, *Brit. Conch.* 1862.

(Plate LVI., figs. 10–16).

Colour very variable, but generally either brown, black, or red, in adults; and either light red or yellow in young ones; wrinkles very long behind middle of mantle, and sharply keeled. Foot generally yellowish, but never white; head and tentacles dark violet.

Synonymy.—Many Continental authors have adopted for this species Férussac's (8) name of *A. empiricorum*, chosen by him because he thought a new name would avoid the confusion arising from Linné's adoption of two designations, viz. "*ater*" and "*rufus*" for varieties of the same species. According to the British Association Code of Rules, however, which is observed by British zoologists, the oldest name or the one standing first on a list shall be used, irrespective of the suitability of the name.

External Characters.—This species is the most variable of our Irish slugs. During youth the number of variations are much larger than in adults, as they almost all darken with age, becoming more uniform in colour.

In Ireland I have up to now met with six very distinct varieties of the adult slug, viz. brown, black, claret-red, salmon-red, olive, and black with yellow sides. In some of these the foot may remain unaffected by the colour, whilst in others the foot becomes more or less coloured too, but I think that is not a point of any importance. The brown variety (Plate LVI., fig. 10) is perhaps the commonest (in the gardens about Dublin, at any rate).

The margin of the foot, in all these varieties, is transversely striated, by which character this slug may be distinguished from all other species of *Arion* except *A. subfuscus*.

The wrinkles are useful in discriminating between *A. ater* and *A. subfuscus*.

In the former the wrinkles on the back, just behind the mantle, are very long, and sharply keeled, whilst in *A. subfuscus* they are hardly half as long, and flat.

Too much importance, however, should not be attached to the shape of the wrinkles. Anyone who has kept this species in captivity can see for himself that, by carefully sprinkling the box in which the specimens are confined with water, the body-wrinkles after a while become more and more flattened out. A specimen which may have had all its wrinkles standing out sharply from the body, in a dry atmosphere, appears quite changed after it has been imprisoned in a damp tin box for a couple of hours. There are naturalists who have manufactured new species of *Arion* merely by the different shapes of the wrinkles; but a little practical observation shows how much they are worth. An adult of *A. ater* cannot be mistaken for *A. subfuscus*, but a young one might, and indeed has been by most writers. A rough and ready method of discriminating between the two species is to give them a tap on the head. *A. ater* will almost immediately draw itself together, and resting on its foot, the arched body will appear nearly equal in length and breadth (Plate LVI., fig. 11). Another tap now will, in almost every case, even in very young specimens, cause the animal to rock about from side to side. This most peculiar motion, which is often continued for several minutes, has never, to my knowledge, been observed in any other slug. A similar tap applied to *A. subfuscus* will merely cause the animal to shrink up, but it will never assume the characteristic hunched position of *A. ater*, nor will any tapping produce the swaying movement.

The margin of the foot is very often of a colour different from the rest of the body; thus in brown specimens the margin may be brick-red. On the Continent specimens of a similar brick-red tint covering the whole body are extremely common, and in central Europe the large majority are of this colour. (This will be referred to again in the Chapter on Colour.) I have never seen an adult brick-red specimen in Ireland.

The head and tentacles are, as a rule, of a dark violet colour. There is no trace of a keel, the back being perfectly rounded.

This species assumes much larger proportions on the Continent than it does in Ireland. The largest I have seen near Dublin measured 90 mm. by 10 mm. On the West Coast specimens of that length, but rather broader, are common. The average size for a full-grown specimen on the East Coast, however, is 60 mm. by 10 mm.

The nature of the mucus varies in proportion to the severity of the stimulus. As a rule colourless, it becomes orange-yellow when the animal is much irritated, and sometimes I have seen it milky like that of *Agriolimax agrestis*.

Anatomy (Plate LVII., fig. 32).—Detailed accounts of the anatomy of this species have been given by Lawson (18), Nunneley (31), and others. I have

examined specimens from Norway and the different parts of Ireland, and find that there is less difference between the East Irish and Norwegian than there is between the West and East Irish.

The colour of the hermaphrodite gland (*hg.*), generally of a light brown, varies according to the colour of the body. The hermaphrodite duct (*hd.*) is well convoluted. The free oviduct (*ov.*) opens into a vestibule as in *Amalia*, but there is in *Arion ater* an additional glandular lower vestibule (*lv.*) which has by Lawson (18) been incorrectly named cloaca. The upper vestibule (*uv.*) or atrium he distinguishes as the "egg-sac."

The sperm-duct (*sp.*) ends in what used to be regarded as a penis, but which Simroth (38) has shown is only the enlarged lower portion of the sperm-duct (*sp.*) in which the spermatophores or sperm-cases are formed. The receptaculum (*rec.*) and the "Patronenstrecke" (*pat.*) of the sperm-duct (*sp.*) opens into the lower portion of the upper vestibule (*uv.*).

Both the oviduct (*ov.*) and the duct of the receptaculum are provided with powerful retractor muscles (*rm.*), which in West Coast specimens are attached quite close to the receptaculum and the upper portion of the oviduct, respectively, whilst in East Coast forms these same muscles are almost invariably attached much lower down to the same structures. Of course this alone may not be of much importance, but coupled as it is with differences in colour and length of life, the West Coast forms constitute what we may at present regard as a striking variety of *A. ater* which may become further modified in time. I propose to reinvestigate this form when I have collected more material in the West.

Reproduction.—The eggs are laid chiefly in August and September, in clusters averaging about fifty in number. I have frequently observed them in fields under heaps of hay and in gardens under stones. They are deposited freely in captivity. They adhere only very slightly to one another, and may be easily distinguished from any of those previously described by their remarkable hardness. They feel quite solid, and owing to their calcareous shells are perfectly opaque. They have a long diameter of 4 mm. and a short one of 3 mm.

I said above that reproduction takes place chiefly in August and September, but a few specimens, undoubtedly, deposit eggs earlier, for I have seen quite young ones in August, and as the eggs take about 4 to 6 weeks to develop, they must have been deposited in June.

Throughout the winter large numbers of young ones are to be met with in the garden, and frost does not seem to affect them very much. These young specimens (figs. 13 and 14) are invariably of a very light yellow or red—never dark. Generally well-defined black lateral bands run along each side of the body, and are continued on the mantle, ending at its anterior margin; and all have dark-coloured heads and tentacles. I have no doubt that these young forms, which are

about 30 mm. long in March, reach their maturity in the following autumn, and I quite agree with Simroth (38), who fixes the limit of age in *A. ater* at one year.

In the month of March the portion of the back and mantle between the lateral bands becomes darker, a condition which is well seen in figs. 11 and 12; and in that case a narrow light stripe is left between the dark portion and the bands. But in some cases the back darkens uniformly, producing forms which have been described by Roebuck as var. bicolor (fig. 15). I have found a half-grown form at Whitechurch, near Dublin, in which the back remained light, whilst the sides darkened (fig. 16). Similar young forms of the var. bicolor have been described by Simroth (38) from the shores of the Baltic, and it is remarkable that every instance of their occurrence is in close proximity to the sea. The light sides in these specimens remain light throughout life. At Raheny, near Dublin, where I have collected extensively last September, fully 30 per cent. were black above with yellow sides, the remainder being entirely black with olive margin of foot. All these had fully-developed reproductive organs. At Howth, Mr. Redding has taken them with brilliant orange sides (fig. 15). In both cases the specimens were found almost within reach of high tide. Only in one instance have I seen this variety further inland in several specimens which were kindly given to me by Mr. A. G. More, from his garden at Rathmines. This lies fully three miles from the sea, but it may be that they found their way to the gardens with plants from the sea-side.

This disposes of the *A. ater* from the East Coast of Ireland. On the West Coast the same species forms a very remarkable variety, possibly owing to the difference of the meteorological conditions. If we look at Scott's (37) latest report on the variability of the temperature in the British Isles, we find that during fifteen years in Valentia Island, the thermometer only descended below freezing point six times. In summer, during the same period, it only once rose above 70° F. (= 21° C.). There is in fact probably no place in Europe where such an equable climate exists as on the South-West Coast of Ireland.

As a result of these favourable meteorological conditions, adult forms of *A. ater* survive the winter, but apparently do not develop reproductive organs in that period. I received a large box of specimens, 80 mm. long, from the Aran Islands in November. Their body cavity was almost entirely filled with a huge liver and intestines, whilst the generative organs were like those of an ordinary half-grown specimen. Again, in May, I collected everywhere in the mainland of Kerry, and on Valentia Island, numbers of specimens considerably larger than our Dublin full-grown forms, but again with hardly a trace of any reproductive organ. Among these an olive-coloured variety is very common, and also one of a cinnamon-red; neither of these is banded. Besides these, rich brown forms, like

those on the East Coast, also occur. Those from the Aran Islands were almost all pitch black.

I only found two specimens with fully developed reproductive organs in my collection, and these were sent to me in August by the Rev. A. H. Delap, from the Skelligs Rock, off Valentia. Thus we probably have the same period of reproduction as on the East Coast, but the specimens either live for two years, or for a year and a-half. The latter seems to me more probable, and we should, in that case, have a second period of reproduction in the early months of spring on the West Coast.

Habitat.—This species is found everywhere in company with *Agriolimax agrestis*, both on the mainland and many of the islands on the West Coast. In the garden it is one of the commonest forms. In my own garden I have never seen an adult of any other colour than a rich brown (fig. 10). Similar brown slugs I have noticed as very abundant on the West Coast. In woods and fields near Dublin I have hardly ever seen this variety. In the Dublin Mountains, at Killakee, all the adult forms I obtained were of a dark claret colour; they resembled very much the fallen pine-needles that covered the ground, and it seemed to me a case of protective colouring.

On the West Coast I have collected at Cahirciveen, Derrynane Bay, and other places in the Co. Kerry, and most specimens were either brown or olive-coloured—sometimes of a salmon-red—and the ground being boggy, again resembled the colour of the slugs. It has been remarked by many observers, and it agrees with my experience, that this slug is more often seen crawling about in the daytime than others. I have especially noticed this fact on the West Coast, where, of course, the climate is exceedingly damp, but it struck me also in the forests of Germany, where one sees so many large red-coloured *A. ater*.

Food.—*A. ater* is undoubtedly a voracious vegetable feeder, preferring decaying chlorophyllaceous plants to fresh ones. I have kept them on campanula leaves for a long time. Kew (17) kept this species in captivity from May to October, during which time twenty-six different substances were eaten. One slug lived on a newspaper for some time. He says—"The dead bodies of *Arion subfuscus*, *A. hortensis*, *Limax maximus*, *L. flavus*, and *L. agrestis*, a dead *Unio*, freshly turned pupae of *Adimonia tanaceti*, a small part of the abdomen of a dragon-fly (*Diplax striolata*), leaves of lettuce, *Scabiosa succisa* and *Solanum nigrum*, flowers of *Pedicularis sylvatica*, *Ranunculus flammula*, *R. acris*, *R. repens* and *R. bulbosus*, and the lichens *Evernia prunastri* and *Ramalina farinacea* were readily fed upon. *Polypodium vulgare*, *Eryngium maritimum*, and berries of *Arum maculatum* were taken in small quantities and with evident reluctance, as also was Pears' soap."

Thompson (43) noticed two specimens of this species busily engaged devouring a snail (*H. aspersa*) which appeared to be freshly killed.

We thus see that although *A. ater* is on the whole a vegetable feeder, it is not particular as to its choice of food, and is always ready to eat almost anything that comes within reach.

General Distribution.—Great Britain, and throughout continental Europe, Algiers (?), Azores (?), Madeira, and Iceland.

Arion subfuscus, Drap.

Limax subfuscus, Draparnaud, *Table Moll.*, 1801. Arion ater (pars), Jeffreys, *Brit. Conch.*, 1862.

(Plate LVI., figs. 17–19.)

Colour either yellowish or light gray; never brown or black. The wrinkles short and flat. Margin of foot white, with gray transverse striæ. Thick yellow slime on body, chiefly near head and tail. Foot and sides of body generally white; sometimes yellowish.

Synonymy.—In such text-books as Jeffreys (16) and Forbes and Hanley (9) this species is grouped under the varieties of *A. ater*, although it had long before been described as a distinct form by Draparnaud (5). I believe that Müller's (28) *A. flavus* is an immature form of *A. subfuscus*, and not identical with Simroth's (38) *A. minimus*, the latter never growing longer than one inch, whilst Müller gives 1½ inch as the size of his slug.

External Characters.—Three varieties of this slug are found near Dublin which, although they do not, as far as I have been able to ascertain, differ anatomically, show considerable external differences. We may, indeed, regard them as species in process of formation. I have had too few specimens to come to a definite conclusion, and further researches may reveal new characters by which they can be separated anatomically.

The typical *A. subfuscus* (Plate LVI., fig. 17) resembles *A. ater* in having the margin of the foot transversely striated, and in having a dark head and tentacles, which, however, are never as dark as those in *A. ater*. The sides are white, and have a semi-transparent appearance like a wax candle. The margin of the foot, and the foot itself is white, the former with delicate gray cross-bars. There is no variety of *A. ater* with a white foot or white sides, and this distinguishes the typical *A. subfuscus* at once. The upper surface is dark gray, becoming lighter towards the very distinct lateral bands. The whole of the back and mantle is almost always covered to such an extent by a thick reddish-yellow mucus, as to obscure the gray colour and make it appear reddish-brown. The mucus is most intense in colour on the anterior portion of the mantle, and near the caudal gland.

To show that this mucus has nothing to do with the real colour of the slug one need only wrap it up in a piece of blotting paper, and roll it about for a moment, when all the mucus will be soaked up. The slug then appears in his natural costume, which is composed of white and a bluish-gray, without any trace of a yellow or red pigment in the skin.

If we subject the two varieties (Plate LVI., figs. 18 and 19) to the same treatment we get a very different result. The first (fig. 18), which, by the way, is not the *A. brunneus* mentioned by Lehmann (20) and Simroth (38), has no lateral bands, but is rather darker on the back than at the sides. It is a yellow slug, but on the mantle we again find the peculiar reddish mucus, and if the latter is soaked up by blotting paper, we have an entirely yellow slug, and the yellow is due to a pigment investing the skin in small granules. Moreover, the space between the wrinkles is of a bluish colour. The second variety (fig. 19) is entirely yellow, with a lateral band on the back. The margin of the foot in both these varieties is yellow, the yellow colour extending also to one-third the breadth of the foot on each side.

I found the typical form of *A. subfuscus* generally between 40 and 45 mm. in length, whilst adults of the first variety were as a rule rather smaller, viz. 35 to 40 mm. Of the second variety I obtained only one specimen, whose reproductive organs, although not fully developed, showed that it was more nearly allied to *A. subfuscus* than to *A. ater*. Recent investigations into the anatomy of the *Arionidæ* such as those of Pollonera (33) and Simroth (40) may throw light on the affinities of this species, which for the present I must regard as a variety of *A. subfuscus* more material is available. My specimen was 55 mm. in length.

The wrinkles in all these slugs differ from those in *A. ater* in being much shorter, which is especially well seen in the wrinkles just behind the mantle. They are much flatter than those in *A. ater*, although one has to guard against the influences of temperature in comparing these in different slugs, as I have had occasion to point out under the heading of *A. ater*. The slime is abundant and clear, and must be distinguished from the intensely yellow mucus which is until produced by the mucus glands on the back and mantle of the slug.

Anatomy (Plate LVII., fig. 33).—The internal organization of this species differs little from that in *A. ater*, but all the different parts, of course, are smaller. The ovisperm-duct (*os.*) is shorter in proportion than in *A. ater*. As in the latter there is no penis, the sperm-duct (*sp.*) ending in a "Patronenstrecke" (*pat.*) in which the spermatophores are produced. This portion opens into the lower part of the duct of the receptaculum (*rec.*), which, in its turn, opens directly into a lower glandular vestibule (*lv.*), the upper vestibule being absent. The genital retractor muscle (*rm.*) is attached to the oviduct (*ov.*) much higher up than in *A. ater* (see fig. 32).

Reproduction.—I found the eggs of the typical *A. subfuscus* commonly at Raheny, near Dublin, at the end of August, and the species also bred freely in captivity. The eggs were mostly about 3 mm. long by 2½ mm. broad, and semi-transparent, much clearer than those of *A. ater*. Similar eggs, but rather smaller, viz. 2½ mm. by 2 mm. were deposited in captivity by the variety shown in fig. 18. The eggs number generally about twenty in a cluster, and were seen from the middle of August to the middle of October. The young forms were not observed, and I have not sufficient data to express an opinion as to its limits of age.

Habitat.—I have taken the typical form of this species very abundantly at Raheny, Co. Dublin.* They were found in fields close to the sea where horses were kept and fungi abounded in autumn. Wherever there was any horse-manure, numbers of *A. subfuscus* were sure to be close by. But I also got them under decaying heaps of weeds in another field in the neighbourhood.

The difference between those found among the manure, and those occurring among the weeds, first drew my attention to the absence of yellow in the skin of these slugs, the colour being entirely due to the mucus. Those found among the weeds secreted hardly any of the yellow mucus, and being white with gray backs, differed at first sight very much from the vividly-coloured specimens found previously.

The first variety (fig. 18) was found in a small pine wood on Howth Hill, near Dublin, about 300 feet above the fields referred to. Similar specimens were obtained on Bray Head, in the Co. Wicklow, and, along with the variety fig. 19, at Killakee in the Dublin Mountains.

Food.—These slugs seem almost entirely to subsist on fungi, chiefly of the genus Russula; but they do not despise the poisonous *Agaricus muscarius*, which proves deadly to flies and other insects. I once observed two specimens eat a fallen poplar leaf in a wood, although plenty of fungi were quite close to them; but it was only after some days that specimens in captivity gnawed at the green leaves of Campanula. Simroth (38) found them, especially in the north of Germany, feeding on all kinds of fungi, and observes that they never colour spirit green, which proves that they do not live on chlorophyllaceous food.

Kew (17) saw *A. subfuscus* devour a dead specimen of its own species, and also an *Amalia marginata* (= *carinata*). In captivity, he observes, they eat bread and leaves of lettuce freely, also the leaves of *Solanum dulcamara* when decomposing. A fungus (*Phallus impudicus*) was eaten voraciously, but the slugs then died, probably owing to the fœtid smell given off by it.

General Distribution.—Great Britain, continental Europe (except Spain and Portugal), Iceland, and Greenland (?).

* I also found it at Glengariff, Co. Kerry.

Arion hortensis, Férussac.

Arion hortensis, Férussac, *Hist. Moll.*, 1819. Arion hortensis (pars), Jeffreys, *Brit. Conch.*, 1862.

(Plate LVI., fig. 20.)

Colour of body generally dark gray or light brown, with bluish-gray sides. Lateral bands somewhat diffuse towards sides of body, always present, and continued to front of mantle. Foot always red, wrinkles broad. The calcareous grains composing shell often more aggregated than in other species. Receptaculum seminis round.

External Characters.—A typical form of this slug is at once recognized from other species by the red colour of the margin, as well as the sole, of the foot. But the intensity of this colour is subject to a good deal of variation, and in many cases the foot is more of a yellowish colour, with just a tinge of red, while sometimes only a faint indication of colouring remains. In such cases *A. hortensis* might well be mistaken for one of the other species. By a little practice, however, we can soon detect other distinguishing characters.

If we take an *A. hortensis* of 20 mm. in length, and compare it with specimens of *A. ater* (Pl. LVI., fig. 16) *A. bourguignati* (Pl. LVI., fig. 21), and *A. intermedius* (Plate LVI., fig. 22) of the same length, the little conical wrinkles will at once eliminate the latter. From *A. ater* the specimen of *A. hortensis* will be distinguished by its dark colour, young ones of the former being always light-coloured; the wrinkles, moreover, in *A. ater* are longer and broader. Sometimes *A. hortensis* is remarkably like *A. bourguignati*, but apart from the wrinkles, which are broader in the former, the lateral bands are somewhat diffuse towards the external edge, as if they had been touched by a wet brush, whilst in *A. bourguignati* their edges are well defined.

If spirit specimens of the same size are taken, which sometimes have lost all trace of colour, the wrinkles must decide, and, of course, as a last resource, the anatomy. If we measure the width of the wrinkles just behind the mantle, we find that in *A. ater* rather more than one, in *A. hortensis* two, and in *A. bourguignati* three wrinkles go to the millimetre.

So much for comparison. As for the general colour of this species, I find that two distinct varieties are as a rule found in the garden. The back of the body and mantle in the first is of a dark gray, becoming lighter towards the lateral bands. Below these the body is of a light, sometimes bluish-gray colour.

In the second variety, which was much more numerous in my garden in September, the back of body and the mantle were as if dusted over with fine yellowish

brown powder, so as to produce a light brown tint (Plate LVI., fig. 20). Below the lateral bands the body colour is a light brownish-gray.

According to Simroth (38) the light colour is produced by warmth, and the dark by cold; but whether this explanation holds good in the case of the two varieties of *A. hortensis* occurring in the same locality at the same time of year, seems to me extremely doubtful. However, I shall refer to this again in the chapter on colour.

The largest specimens of this species were 35 mm. long. The mucus is yellow and somewhat sticky.

Anatomy (Plate LVII., fig. 34).—As in the other species the characteristic part of the anatomy is to be found in the lower portion of the reproductive organ. As in *A. ater* there is an upper (*uv.*) as well as a lower vestibule (*lv.*). The free oviduct (*ov.*) is long and widened in its lower part. The sperm-duct (*sp.*) ends in a somewhat swollen "Patronenstrecke" (*pat.*), whilst the long-stalked receptaculum (*rec.*) is round. The genital retractor muscle (*rm.*) divides into two bundles, one going to the duct of the receptaculum, the other to the oviduct.

The calcareous grains under the mantle are, in this species, often aggregated so as to form a rudimentary shell, which, according to Lessona and Pollonera (21) in Italian specimens is well developed.

Reproduction.—I kept about fifty specimens in captivity from the middle of September to the end of October, but no deposition of ova took place, nor did I ever see ova that I could refer to this species. Simroth (38) had some eggs deposited by captive specimens, which were perfectly round and clear, with a diameter of 2 mm.

It is remarkable that very young specimens of this species have a keeled back, but this keel, not being different in colour from the surrounding wrinkles, is not very easily seen—and it entirely disappears in half-grown specimens.

It seems to me probable that the deposition of ova takes place in the early months of summer or spring, but additional observation is needed also with regard to the duration of life in this species. All the specimens I have seen during winter were pretty large, mostly half-grown, which leads me to suppose that no deposition of ova takes place during autumn.

Habitat.—Simroth (38) states that *A. hortensis* is a South European form, and probably does not occur north of the 52° of latitude. However, he has since examined the Irish forms, and pronounced them identical with the German ones, so that we may safely conclude that it does extend considerably farther north than Simroth anticipated.

The same author states that he has never met with a specimen anywhere but in gardens, churchyards, and within villages.

In Ireland, although also very common in gardens, it certainly has a wider

range. I have found it in a wood at Kilruddery, in Co. Wicklow; also at Killakee, in the Dublin Mountains, and other places far removed from cultivated ground.

It seemed to me remarkable never to meet with the brown, or yellowish variety in the open country—all were of a dark bluish-gray, and the foot always more yellowish than red.

Although I did not find this species in Kerry, Miss Warren kindly sent me half a dozen specimens from Sligo, and it has also been recorded by Thompson (43) from the North of Ireland.*

Food.—I had great difficulty in keeping this species in captivity, and its numbers diminished rapidly until they all died. Pieces of apple and Campanula leaves were eaten, but neither appeared to be relished; and I am inclined to think that *A. hortensis* lives chiefly on decaying vegetation, as they are most numerous in the garden among heaps of old weeds. I have never found it on fungi. Simroth (38) believes that it is a vegetable feeder, and that it is especially partial to heavy soil. Gain (10) also found that *A. hortensis* was rather sickly in confinement, but he states that 60 per cent. of the foods offered were taken.

General Distribution.—Great Britain and Continental Europe, except Scandinavia and Russia.

Arion bourguignati, Mabille.

Arion bourguignati, Mabille, *Rev. et Mag. de Zool.*, 1868. Arion hortensis (pars), Jeffreys, *Brit. Conch.*, 1862.

(Plate LVI., fig. 21.)

Colour light gray or reddish gray. Lateral bands on body continued to front of mantle. Foot always white. Wrinkles narrow. A distinct keel in young specimens. Receptaculum seminis elongate.

External Characters.—As I have pointed out above, this species is so much like *A. hortensis* that the two species are still by many conchologists mistaken for one another.

The brilliantly white foot is one of the best distinguishing characters, but by the mere touch one is often able to discriminate between the two forms, as *A. bourguignati* is always much less slimy. The wrinkles are narrower, and its whole appearance is more slender. Young specimens, as pointed out by Mabille (24), are at once recognized by the keel which, owing to its white colour is rather conspicuous. It is a somewhat smaller species than *A. hortensis*, the maximum length reaching as a rule not more than 32 mm.

* I have since found it in Wexford and Queenstown, in the South, and in Connemara, in the West of Ireland.

As in the other, there are two varieties in colour, but in the garden I have never met with the dark form. The young, both in the open country and garden, are delicately gray, with a well-defined lateral band on each side of the body and mantle. The colour remains the same in the garden forms as they grow up, but a number of reddish pigment spots appear, which produce a general effect of tan-colour. In the country specimens I have never observed this development of red pigment, and the original gray colour merely darkens, so as to produce a dark-gray slug.

Anatomy (Plate LVII., fig. 35).—Although this and the preceding species are difficult to distinguish externally, anatomically *A. bourguignati* presents unmistakable characteristics.

The hermaphrodite gland (*hg.*) is dark-brown and round. The free oviduct (*ov.*) which is long in *A. hortensis*, is here quite short, whilst on the other hand, the sperm-duct (*sp.*) is longer in *A. bourguignati*, and the "Patronenstrecke" (*pat.*) is not swollen. But perhaps the most apparent difference between the two species is the shape of the receptaculum (*rec.*) which in this species terminates in a long pointed apex. *A. bourguignati* has only one large vestibule (*lv.*), viz. the lower, whilst in *A. hortensis* there are two.

Reproduction.—I have not been able to observe the deposition of eggs in this species, although large numbers of specimens were kept in confinement during the months of September and October.

This and the almost complete absence of adults in September lead me to think that reproduction takes place early in the summer. This agrees with Simroth's (38) observations, who also found only half-grown forms during winter.

Habitat.—This species is not nearly so common as the preceding one, but still it has a wide distribution in Europe. I have obtained it commonly in my garden where the soil is heavy, and also among moss and under stones in the Dublin Mountains. In Kerry I found it on Valentia Island and at Lough Caragh, whilst Miss Warren sent me a specimen from Ballina, in Sligo.

I met with the largest specimens in June and July, but never in the daytime. This, no doubt, accounts for the fact of its having been comparatively rarely met with on the Continent, for Simroth (38) states that it is rare during summer, whilst Mabille (24) speaks of it as "une espèce d'hiver."

Food.—Like the last, this species does not thrive in captivity, and although they will nibble at pieces of apple and rhubarb stalk, they appear to me to prefer decaying vegetation. I never found it among fungi, but in my garden, when it emerged from the ground early in the evening along with *Agriolimax agrestis*, it, as a rule, remained on the ground, whilst the latter ascended the pea plants, and did a great deal of damage by eating the young shoots and flowers. It seemed to me

as if *A. Bourguignati* preferred to feed on the fallen flowers which were partially decomposed, instead of attacking the living parts of the plant.

Gain's (10) experience is very different from mine, for he says: "This slug ate exactly one-half of the foods given, and thrives and breeds freely in confinement."

General Distribution.—Great Britain, and continental Europe, except Spain and Portugal, and Siberia (?).

Arion intermedius, Normand.

Limax intermedius, Normand, *Descr. Lim.*, 1852. Arion hortensis (pars), Jeffreys, *Brit. Conch.*, 1862. Arion minimus, Simroth, *Zeitschr. wiss. Zool.*, 1885.

(Plate LVI., figs. 22, 23.)

Colour light yellow or gray, with abundant yellow slime chiefly near head and caudal gland. Wrinkles with little conical spikes. Lateral bands either absent or very faint. It occurs chiefly on fungi.

Synonymy.—Simroth (38) was the first to re-establish on anatomical grounds the claims of this form to rank as a distinct species. Finding no satisfactory description of any species corresponding to his own, he called it *Arion minimus*, which name I temporarily adopted in a preliminary notice sent to the Conchological Society (36). Since the publication of his monograph, Simroth consulted the writings of older authors, such as Müller (28) and Nielsson (29), but as their *A. flavus* seemed to have been a larger slug, probably a young *A. subfuscus*, he thought his name (*A. minimus*) should be retained. Gmelin (11) and Férussac (8) merely repeated Müller's description without apparently having seen the slug. Among Moquin-Tandon's (26) uncertain species, we find *A. flavus* again, and there is no doubt that the author of the "Mollusques terrestres et fluviatiles de France" really had specimens of our slug before him, which he believed was the same as that referred to by Müller, Gmelin, and Férussac. But as Pollonera (32) has pointed out, the priority rests with another French author, viz. Normand (30), who described the same species under the name of *A. intermedius* three years before him.

External Characters.—This is the smallest of our Arions, and the only one besides *A. ater* which when at rest assumes the peculiar arched position (fig. 23). When examined in that attitude with a pocket lens we find that the wrinkles project in the shape of little conical knobs, and these give the slug that glittering appearance by which it is easily recognized from the other species.

The colour of *A. intermedius* is almost always white, or sometimes light gray, but owing to an abundant yellow mucus it often appears canary-yellow, especially near the caudal gland. The foot also is yellow, due to the same cause. The head and tentacles are dark gray.

The bands are sometimes completely absent, but when present, they are very faintly marked and diffuse, both on the body and mantle. I think the nature of the lateral bands and the wrinkles are the two most characteristic features in this slug.

Compared with *A. Bourguignati*, for which dark specimens might be mistaken, the touch alone will help us to some extent, *A. intermedius* being much softer, and leaving a bright yellow watery mucus behind, whilst the former is thick-skinned, with a sticky white mucus. The habitat will also distinguish the two species, as they are never found in company.

Anatomy (Plate LVII., fig. 36).—The reproductive organs, as has been shown by Simroth (38) approach those of *A. subfuscus* more than those of any other form.

The oviduct (*ov.*) is short and straight, the receptaculum seminis (*rec.*) round, and the sperm-duct (*sp.*) scarcely swollen in the "Patronenstrecke" (*pat*). These open into a large vestibule (*lv.*).

Reproduction.—The clusters of eggs which I observed very frequently in August and September never exceeded twenty. The eggs are remarkably large for the size of the slug, being 2 mm. long by $1\frac{1}{2}$ mm. broad. The young ones of 8 mm. in length, which I bred in captivity, were of a light gray, owing to the intestine being visible through the semi-transparent walls of the body. The head was of a delicate gray, and no bands were visible on the body or mantle. Still younger ones, of 3 mm. long, were of a very light red, with violet tentacles, and had emerged from the egg three weeks after their deposition. Their limit of age has been determined by Simroth (38) as not exceeding one year. I myself found adults up to the middle of October, but not by any means so commonly as during August and September.

Habitat.—This slug is never met with in the garden or on cultivated ground. I found it for the first time last August in a field under a heap of decayed weeds at Raheny, near Dublin, in company with *Arion ater*, *A. subfuscus*, *Amalia gagates*, and *Agriolimax agrestis*. Shortly after, I obtained numerous specimens close by feeding on common mushrooms (*Agaricus*) and fungi, which had appeared in the fields.

In the Earl of Meath's demesne at Kilruddery, county Wicklow, this slug is common; also at Killakee in the Dublin Mountains. In fact, wherever there are fungi one is sure to find it, but, like *A. subfuscus*, it takes green food pretty freely in captivity. No doubt, *A. intermedius* has a wide range, but up to the present I have only taken specimens in the neighbourhood of Dublin, whilst one was sent me by the Rev. A. H. Delap, from Lough Caragh, in Kerry. This latter was of a uniformly dark gray colour.*

Food.—The nature of the food has already been referred to above. *A. inter-*

* I have since taken them in Connemara, in the West of Ireland.

medius is a most typical fungus-eating slug, and I have chiefly found them on species of *Russula*, *Agaricus*, and *Clavaria*.

General Distribution.—Great Britain, Scandinavia, Germany, France, Italy (?), and probably introduced in New Zealand.

Genus V. **Geomalacus**, Allman, 1846.

Body sub-cylindrical; pulmonary opening on front of middle of mantle. Genital pore near base of upper tentacles. Caudal gland opening by transverse slit. There is a solid internal shell.

This genus was established by Allman (1) to include the most interesting of Irish slugs.

At first sight a *Geomalacus* looks very much like an *Arion*, but the end of the body which in that genus is pointed, and contains the longitudinal opening of the caudal gland, is, in *Geomalacus*, rounded off, so that the caudal gland opens by a transverse slit between body and foot.

The reproductive pore or genital opening lies close to the tentacles, as in the genus *Limax*, whilst in *Arion*, as we have seen, it is situated near the pulmonary aperture.

As for the anatomy, the distinctive characters of *Geomalacus maculosus* will be mentioned below, so that it remains only to be said that there is a solid internal shell, something like that in *Limax*, but very different from the calcareous particles found in *Arion*. Only one species has hitherto been found in Ireland, and it occurs nowhere else in Europe, except in North-western Spain and North Portugal. Two other species of *Geomalacus* (*G. oliveirae* and *anguiformis*) have been found in Portugal, but only short descriptions of their external characters have appeared as yet.

Mabille (23) in a Paper on the genus *Geomalacus*, described several species of French slugs, which he believed to be of this genus, but it has already been clearly demonstrated by Heynemann (13) that this view is entirely without foundation. They really belong to the genus *Arion*.

Geomalacus maculosus, Allman.

Geomalacus maculosus, Allman, *Ann.* and *Mag. Nat. Hist.* 1846. Geomalacus maculosus, Jeffreys, *Brit. Conch.* 1862.

(Plate LVI., fig. 24.)

Colour dark gray, with light yellow or whitish spots on body and mantle.

External Characters.—The figures given by Heynemann (13) in his excellent

Paper on this species, are much better than Allman's original drawings, in spite of the fact of the latter having been executed by so able a draughtsman as the late Mr. Du Noyer. Du Noyer's figures are pretty, but idealized. The only point in Heynemann's figures which I take exception to is the caudal portion of the body. This should not be so flat, but more raised as in my figure 24. Forbes and Hanley (9), Jeffreys (16), and others, seem to have merely copied Allman's figure.

This slug was discovered in the county Kerry, in the autumn of 1842, by the late William Andrews of Dublin, who placed it in the hands of Dr. Allman; and it was first exhibited at a meeting of the Dublin Natural History Society in January, 1843. The skin is always smooth and shiny, and not black, but of a dark gray colour.

Both on the mantle and back there are a series of yellowish-white or yellow spots. These seem at first sight quite irregularly placed on the body, but Simroth (39) has drawn attention to the fact that on closer inspection there appear traces of distinct longitudinal bands, as in *Arion*. In most cases, indeed, I have observed these very well, but in others the banding is very difficult to demonstrate. The margin as well as the sole of the foot are of a dirty white. The tips of the tentacles are cylindrical, whilst in the genus *Arion* they are round. The mucus is transparent and limpid. The largest specimen measured about 55 mm. in length.

Mabille (23), in his Paper on the genus *Geomalacus*, referred to on p. 551, has attempted to set up a second species, which he calls *G. andrewsi*. His assumption is based on Allman's original description, who mentions, besides the common form, a white-spotted variety. Mabille believed that this meant a white, spotted variety, *i.e.* a white slug with black spots, and, astounding as it may appear, proceeded on these grounds to describe it as a new species.

Anatomy (Plate LVII., fig. 37).—Heynemann (13) does not deal with the anatomy of this slug, excepting in a reference to the shell and the tongue, neither of which is of very great importance. The latter is very much like that of an ordinary *Arion*, but the shell is firm and regular like that of a *Limax*.

The fact that the calcareous particles often congregate together in *Arion intermedius*, and form a kind of irregular shell, has induced French authors, such as Mabille (23) and Baudon (2), to start the idea that this slug must be a *Geomalacus*; but the shell in the genuine *Geomalacus* is of a very different nature. The intestine resembles that of *Arion*, but the reproductive organs differ widely.

The penis (*p*) is formed by the enormously developed duct of the receptaculum seminis (*rec.*), and not by the oviduct, as in *Arion*. There is a long retractor muscle (*rm.*) attached to the penis at the part where the sperm-duct opens into it. The sperm-duct (*sp.*) is very much longer than in any *Arion*, whilst the ovispermduct (*os.*) is shorter.

Reproduction.—I found a few half-grown specimens along with the adults last May, but did not observe the eggs. Dr. Simroth very kindly sent me the proof-sheet of his large Memoir on the Slugs of Portugal and the Azores (40), and in it I find a statement that a Signor de Silva e Castro had seen the eggs. They were quite transparent, and very large, measuring from 5 to 7 mm. long, and 3 mm. broad. Simroth obtained about 40 young ones at Las Caldas de Gerez, in Portugal.

Habitat.—The first living specimens I have seen were presented to me last April by Mr. A. G. More. They had been collected on the eastern shores of Lough Caragh, in county Kerry, the same locality where Andrews had originally discovered the slug.

In the following May, while returning home from the dredging expedition to the West Coast, organized by the Royal Dublin Society, I passed Lough Caragh, and spent a portion of the night in hunting for this interesting slug, but without success. The following morning I walked to the eastern shores of the lake, and although I turned over hundreds of stones, I discovered nothing but *Limax maximus*, *L. marginatus*, and *Arion ater*. I was about to give up the search, when I noticed a young specimen concealed among the lichens which grow here so abundantly on the surface of the rocks, and, after a while, I found several others similarly exposed to the full rays of the sun, it being then about two o'clock in the afternoon.

The dark gray lichens, with the white or yellowish fructification, conceal the slug perfectly, and there is no doubt that we have here a most striking instance of protective colouring. Lough Caragh is situated close to the head of Dingle Bay, in County Kerry, and, up to quite recently, it was the only spot in Ireland where this slug had been found, but, during last autumn, Mr. Scully discovered it about twenty-five miles further south, on the Kenmare and Glengariff road.*

I notice in Simroth's (40) proof, referred to above, that he found this species among lichens at the foot of a granite wall in the province of Minho, in Northern Portugal. A single specimen was collected in 1868, according to Heynemann (13), by Lucas Von Heyden, in the province of Asturias, in Northern Spain. Two other species, *G. oliveiræ* and *G. anguiformis*, from Central and Southern Portugal, will be described in Simroth's forthcoming Memoir (40).

Food.—*G. maculosus* undoubtedly lives on lichens, as I have been able to demonstrate by microscopic examination of the contents of the intestine.

In captivity it readily takes to other food, and thrives on dandelion leaves; and Heynemann (13) succeeded in keeping Irish specimens during a whole winter on lettuce, gherkins, &c.

General Distribution.†—Northern Portugal, and N. W. Spain.

* In May, 1891, I found this species abundantly still further South at Glengariff, county Cork.

† The question of the peculiar geographical distribution of this slug will be dealt with in a special Memoir, which I hope to publish during the course of this year.

The Colours of Slugs.

A good deal has been written in various Zoological works on the colours of animals in general, and Poulton has recently published a most interesting work, chiefly on the colours of Insects. He finds that a variety of causes influence the production of colours, but that by far their most widespread use is to assist an animal in escaping from enemies or in capturing its prey.

The view that colour is of direct physiological value to slugs has been ably argued by Simroth in the cases of *Arion ater* and *Limax maximus*, and Eimer (6) seems to support Leydig's view, that the darker colour of *A. ater* on the sea-coast may be caused by the greater moisture of the atmosphere. However, I hope I shall be able to show that neither of these views are altogether borne out by facts. Cockerell (4), judging from some specimens sent to him from a mountain in county Waterford, draws the conclusion that altitude influences the colour of slugs, but this also, I believe, is not supported by sufficient evidence.

I think that the colours of slugs in Ireland are at all ages, as a rule, protective. Simroth (38) agrees with this as far as the smaller species are concerned, but he excepts *Limax maximus* and *Arion empiricorum* (= *ater*), because they are often distinguished by strikingly vivid colours.

He made numerous experiments with the latter species, kept it in a hot atmosphere, and offered it to various birds as food, and finally came to the conclusion that the colour in the brick-red variety is a warning colour. The object of a so-called warning colour, I may say, is to render the animal as conspicuous as possible, in order to enable its enemies to easily learn and remember the animals which are to be avoided on account of any noxious properties they may possess.

Simroth (38), moreover, points out that all the very variable species of slugs, such as *Arion ater* and *Limax maximus*, are darkly coloured both at their southern and northern limits of range, the shores of the Mediterranean, and Scandinavia. He supposes this to be due to a natural protection against heat and cold, *i.e.* he believes that colour is of direct physiological value.

We know, however, that dark colours absorb radiant heat easily, while light colours do so with difficulty; and it seems therefore surprising that Simroth (38) did not take into account the fact that the white variety of *A. ater* in Scandinavia is almost as common as the black [Esmark (7)]. Both on the Continent and in Ireland the young of *A. ater* are brilliantly coloured during winter, and most specimens darken at the approach of summer.

If Simroth's theory were correct, one would expect the slugs which are destined to resist the severe cold of a Continental winter to be coloured dark. All young specimens, however, whether they produce black or brown adults, are light-coloured

in their youth, and the colour of the adults varies between black, brown, and red in Germany, just as it does in Ireland, with the exception that the brick-red form so common in Germany is absent with us.

Simroth's experiment of offering *A. ater* as food to various birds, and its being refused by them, does not seem to me conclusive, as birds kept in captivity get a regular diet, and become in time rather dainty feeders. Besides, large birds such as gulls, are decidedly rare in Germany, and I think it much more likely that toads or some of the insectivorous mammals do a great deal of damage among slugs; and it is possibly these that have a particular aversion to the bright red slugs, owing to their more acrid slime. Their colour is certainly most conspicuous, and on a rainy day they are often seen in hundreds in broad daylight in the forests of Germany.

I do not believe their colour is influenced by the temperature, for we find black and brown forms of the same species living in such a dry climate as that of Eastern Germany and on the very humid West Coast of Ireland—in cold and bleak Norway as well as on the parched plains of Spain and Portugal.

In this country, as I mentioned before, I have met with the uniformly black, the brown, olive, claret, and light red varieties of *A. ater*, and one variety which is black above, with yellow sides. The olive and light red forms occur only on the West Coast, but the black and brown ones are equally common there. In boggy ground most of those I saw were either olive or a rich burnt sienna brown. Their colour harmonizes most perfectly with the brown of the turf and the olive-coloured moss growing on it. I have also observed the light red in that neighbourhood, but no natural object seemed to me to exactly resemble it.

Perhaps the wettest spot on the West Coast is the Skellig Rock, an immense rock, entirely bare, over the greater part of which the huge Atlantic waves break, scattering their spray completely over the highest parts. From this rock I have the olive and black variety of *A. ater*. If moisture caused darkness, they would all be black there, for a more humid place can scarcely be imagined.

Certainly, I have everywhere met with black specimens very close to the sea, both on the West and especially on the East Coast, and that fact taken alone might lead us to suppose that moisture had something to do with the darkness of their colour; but black specimens are equally common inland a long way from the sea, whilst on cultivated ground, even if it should be quite close to the shore, we find almost invariably the brown variety.

Another remarkable circumstance is that along the sea-shore near Dublin one meets very frequently with the black and yellow variety, *i.e.* black with yellow sides (Plate LVI., fig. 15.) A variety with white sides has been recorded from the coast of Wales, and Simroth obtained them also from the shores of the German Ocean.

It seems clear that the sea has some connexion with this variety at any rate, but I think its connexion is only of an indirect nature. It struck me at first that the sides of the slugs might be more stimulated to secrete mucus than the back, as the animals would have to crawl over grass which must be coated with depositions of salt; but why should they not then all be of that variety near the sea? Entirely black ones are, in fact, rather more common.

There is another more likely explanation to account for the fact of the bicoloured dress of the young being retained in the adult on the sea-shore. It appeared to me that in the twilight of morning and evening the black-and-yellow forms might have equal advantages of concealment with the black ones, when crawling among the stones at the sea-shore, for I believe this species is just as much preyed upon as other slugs by the innumerable birds frequenting Dublin Bay. It is well known that the gizzard of gulls is frequently found to be filled with slugs of all kinds, whilst Thompson (43) often found the shell of *Limax maximus* and *Agriolimax* in the stomach of the thrush.

The only place where I have found the claret-coloured variety was in pine woods at Killakee and Howth, where the general colouring of the ground resembles that of the slug, and at once suggested to me the protective character of its colour. As regards the young winter forms of *Arion ater*, I have always noticed that they choose the yellow fallen leaves, whose colour they resemble very closely, for hiding-places, and here again it is the need of protection and not temperature which influences their colouring.

As for the other species of slugs, we have very good examples of protective colouring in *Limax marginatus*, *Amalia carinata*, *Arion intermedius*, and *Geomalacus maculosus*. The first, when on a tree-trunk, which is its favourite haunt, is easily mistaken for a piece of bark; the second resembles the ground in which it spends almost its entire existence; the third looks very like a little fungus just coming out of the ground, while the last imitates the colour of the lichen among which it lives to a remarkable degree.

In the other slugs protective colouring is perhaps not quite so apparent, but I have no doubt that in all cases their colour is mainly influenced by the natural selection of those best suited to escape the keen sight of their enemies.

PAPERS AND WORKS REFERRED TO.

1 ALLMAN, G. J., . "Description of a new Genus of pulmonary Gastropod."—Ann. & Mag. Nat. Hist., vol. 17, 1846.

2 BAUDON, AUG., . "Mémoire sur les Limaciens du Département de l'Oise."—1871.

3 CLARKE, B. J., . "On the species of *Limax* found in Ireland."—Ann. & Mag. Nat. Hist., vol. 12, 1843.

4 COCKERELL, T. D. A., "*Limax arborum* and the influence of altitude on colour."—Zoologist, vol. 10, 3rd ser., 1886.

5 DRAPARNAUD, J., . "Hist. nat. des Moll. terr. & fluv. de France."—1805-31.

6 EIMER, G. H. T., . "Organic Evolution."—(Translated by J. T. Cunningham), 1890.

7 ESMARK, BIRGITHE, . "Land and Freshwater Mollusca of Norway."—Journal of Conchology, vol. 5, 1886-88.

8 FÉRUSSAC, A.E., . "Histoire nat. des Mollusques."—1819.

9 FORBES AND HANLEY, "History of British Mollusca."—4 vols, 1853.

10 GAIN, W. A., . "A few notes on the Foods and Habits of Slugs and Snails."—Naturalist, 1889.

11 GMELIN, J. F., . "Systema nat."—1788-90, XIII ed.

12 HANITSCH, R., . "Contributions to the Anatomy and Histology of *Limax agrestis*—Proceed. Soc. Liverp., vol 2, 1888.

13 HEYNEMANN, D. F., "Über *Geomalacus*."—Malakozool. Blätter, vol. 21, 1873.

14 do. "*Limax brunneus*, Drp."—Malakozool. Blätter, vol. 19, 1872.

15 do. "Über *Limax variegatus*, Drp."—Malakozool. Blätter, vol 7, 1861.

16 JEFFREYS, J. G., . "British Conchology."—vol. 1, 1862.

17 KEW, H. W., . "Notes made in 1888 upon *Arion ater* and some other Slugs."—Naturalist, 1889.

18 LAWSON, H., . "General Anatomy of *Limax maximus*."—Microsc. Journal, vol. 3, N. S., 1863.

19 LEACH, W. E., . "Synopsis of the Mollusca of Great Britain" (Proofs published in 1820).

20 LEHMANN, R., . "Die lebenden Schnecken und Muscheln in Pommern."—1873.

21 LESSONA und POLLONERA, "Monographia d. Limacidi italiani."—1882.

22 LISTER, M., . "Synopsis Conchyliorum, &c."—1685.

23 MABILLE, M. J., . "Le Genre *Geomalacus* en France."—Revue et Mag. de. Zoologie, vol. 19, II. ser., 1867.

24 do. "Les Limaciens européens."—Revue et Mag. de Zoologie, vol. 20, II. ser. 1868.

25 MALM, A. W., . "Skandinaviska Land Sniglar."—1870.

26 MOQUIN-TANDON, A., "Hist. nat. d. Moll. terr. et fluv. de France."—1855.

27 MORELET, A., . "Descr. d. Moll. terr. et fluv. du Portugal."—1845.

28 MÜLLER, O. F., . "Vermium terrest. et fluv. historia."—1774.

29 NIELSSON, S., . "Hist. Moll. Sueciae terr. et fluv."—1822.

30 NORMAND, N. A. J., . "Descr. de six Limaces nouvelles."—1852.

31 NUNNELEY, Th., . "Descr. of the Limaces found in the neighbourhood of Leeds."—Trans. Leeds Phil. and Lit. Society, 1837.

32 POLLONERA, C., . "Specie nuove o mal conoscieute di Arion europei."—Atti d. R. Acad. di Torino, vol. 22, 1886–87.

33 do. "Nuove contribuzioni allo studio degli Arion europei."– Atti. d. R. Acad. di Torino, vol. 24, 1889.

34 REEVE, L., . "Land and Freshwater Mollusca of the British Isles."—1863.

35 ROEBUCK, W. D., . Numerous Notes and Papers.—Journal of Conchology, vols. 4-6, 1883–1890.

36 SCHARFF, R. F., . "*Arion minimus* (Simroth) a British Slug."—Journal of Conchology, vol. 6, 1890.

37 SCOTT, R. H., . "The Variability of the Temperature in the British Isles."—Proc. Roy. Soc., vol. 47, 1890.

38 SIMROTH, H., . "Naturgesch. d. deutsch. Nacktschnecken."—Zeitschr. f. wiss. Zoologie, vol. 42, 1885.

39 do. "Über bekannte und neue palaearkt. Nacktschnecken."—Jahrb. d. deutsch. Malakoz. Gesellsch., vol. 13, 1886.

40 do. "Die Nacktschnecken d. portugies-azorisch Fauna."—Nova Acta Acad. C. L. C. G. Nat. Cur., vol. 56, 1891 (Proof).

41 TAYLOR, J. W., . Numerous Papers and Notes.—See Journal of Conchology, vols. 1–6.

42 TAYLOR AND ROEBUCK, "Materials towards a Land and Freshwater Moll. Fauna of Ireland."—Proceed. R. I. Acad., ser. 2, vol. 4, 1888.

43 THOMPSON, W., . "Natural History of Ireland," vol. 4, 1856.

44 WESTERLUND, C. A., "Fauna Europea Moll. extra marinorum," 1877–78.

EXPLANATION OF PLATE LVI.

EXPLANATION OF PLATE LVI.

Fig.

1. *Limax maximus*, L., dark variety (rather more than half-grown), from Raheny, Co. Dublin.
2. ,, ,, (not quite half-grown), from Leeson Park, Dublin.
3. ,, *flavus*, L. (full-grown), from Raheny, Co. Dublin.
4. ,, *marginatus*, Müller (full-grown), from Killakee, Co. Dublin.
5. *Agriolimax agrestis*, L. (full-grown), from Leeson Park, Dublin.
6. ,, ,, L., variety (full-grown) from Rathfarnham, Co, Dublin.
7. ,, *laevis*, Müller (twice natural size, almost full-grown), from Killakee, Co. Dublin.
8. *Amalia carinata*, Leach (full-grown), from Leeson Park, Dublin.
9. ,, *gagates*, Drap. (full-grown), from Raheny, Co. Dublin.
10. *Arion ater*, L., brown variety (full-grown), from Leeson Park, Dublin.
11. ,, ,, variety (half-grown), resting position, from Raheny, Co. Dublin.
12. ,, ,, variety (half-grown), not fully extended, from Howth, Co. Dublin (Redding).
13. ,, ,, variety (young), from Killakee, Co. Dublin.
14. ,, ,, brown variety (young of fig. 10), from Leeson Park, Dublin.
15. ,, ,, variety (half-grown), from Howth, Co. Dublin (Redding).
16. ,, ,, variety (half-grown), from Rathfarnham, Co. Dublin.
17. ,, *subfuscus*, Drap. (full-grown), from Raheny, Co. Dublin.
18. ,, ,, variety (full-grown), from Howth, Co. Dublin.
19. ,, ,, variety (full-grown, sexually undeveloped), Killakee, Co. Dublin.
20. ,, *hortensis*, Fér., brown variety ($1\frac{1}{2}$ times natural size, full-grown), Leeson Park, Dublin.
21. ,, *bourguignati*, Mabille, brown variety ($1\frac{1}{2}$ times natural size, full-grown), Leeson Park, Dublin.
22. ,, *intermedius*, Normand (full-grown), from Raheny, Co. Dublin.
23. ,, ,, ,, variety (full-grown), resting position, from Killakee, Co. Dublin.
24. *Geomalacus maculosus*, Allman (full-grown), from Shore of Lough Caragh, Co. Kerry.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EXPLANATION OF PLATE LVII.

LETTERING ADOPTED IN ALL THE FIGURES.

hg.	hermaphrodite gland.
hd.	hermaphrodite duct.
ag.	albuminiparous gland.
os.	ovisperm-duct.
ov.	oviduct.
sp.	sperm-duct.
rec.	receptaculum seminis.
p.	penis.
rm.	genital retractor muscle.
fl.	flagellum.
pat.	portion of sperm-duct in which spermatophore is formed (Patronenstrecke).
uv.	upper vestibule.
lv.	lower vestibule.
ac.	accessory gland.

EXPLANATION OF PLATE LVII.

Fig.

25. *Limax maximus*, L. (reproductive organs), very dark form, from Killakee, Co. Dublin, October, 1890.

26. ,, *flavus*, L. (reproductive organs), from Raheny, Co. Dublin, October, 1890.

27. ,, *marginatus*, Müller (reproductive organs), from Co. Wexford, August, 1890.

28. *Agriolimax agrestis*, L. (reproductive organs), magnified, from Aran Islands, October, 1890.

29. ,, *laevis*, Müller (reproductive organs), magnified, from Killakee, Co. Dublin, September, 1890.

30. *Amalia carinata*, Leach (reproductive organs), magnified, from Aran Islands, October, 1890.

31. ,, *gagates*, Drap. (reproductive organs), from Raheny, Co. Dublin, September, 1890.

32. *Arion ater*, L. (reproductive organs), black variety, from Raheny, Co. Dublin, August, 1890.

33. ,, *subfuscus*, Drap. (reproductive organs), magnified, from Raheny, Co. Dublin, September, 1890.

34. ,, *hortensis*, Fér. (reproductive organs), magnified, from Leeson Park, Dublin, October, 1890.

35. ,, *bourguignati*, Mabille (reproductive organs), magnified, from Leeson Park, Dublin, July, 1890.

36. ,, *intermedius*, Normand (reproductive organs), magnified, from Raheny, Co. Dublin, September, 1890.

37. *Geomalacus maculosus*, Allman (reproductive organs), from Co. Kerry, May, 1890.

25. Limax maximus
26. Limax flavus
27 Limax marginatus
28. Agriolimax agrestis
29. Agriolimax laevis
30. Amalia carinata
31. Amalia gagates
32. Arion ater
33. Arion subfuscus
34. Arion hortensis
35. Arion bourguignati
36. Arion intermedius
37. Geomalacus maculosus.

F. Huth, Lith^r Edin^r

XI.

ON THE CAUSE OF DOUBLE LINES AND OF EQUIDISTANT SATELLITES IN THE SPECTRA OF GASES. By GEORGE JOHNSTONE STONEY, M.A., D.Sc., F.R.S., Vice-President, Royal Dublin Society.

[Read March 26 and May 22, 1891.]

CONTENTS.

CHAPTER I.

INTRODUCTION.

The study of the kinetic theory of gases has been pursued during the last forty years with great success, by Clausius, Clerk Maxwell, and others, and has thrown a flood of light upon the conditions under which the molecules of ponderable matter subsist in the world about us. By these investigations it was discovered that, while in solids and liquids they are so crowded together as to be unremittingly under the influence of one another, a very different state of things prevails in gases. In gases the moments of time during which the molecules are close enough to act on one another are brief compared with much longer intervals which elapse between their encounters. During these comparatively long periods of independence each molecule is free to move in its own natural way; and important physical events on a large scale take place as a consequence of the motions within the molecules which then occur.

Previously to these inquiries, Dulong and Petit had obtained by experiment the law that the specific heat at constant volume of the more perfect gases is inversely proportional to their specific gravity. It is further known by experiment that γ,

the ratio of the specific heat at constant pressure to the specific heat at constant volume, is nearly the same for all these gases, and that its value is 1·408.

From these data the kinetic theory of gases enables us to gain our first insight as to what is going on within the molecules. These experiments, when interpreted by its help, show that only 0·612 of the energy in the more perfect gases is accounted for by the motions of the molecules as they dart about amongst one another like missiles, and that the remaining 0·388 of the whole energy is the energy of events that are going on *within the molecules themselves.*

We learn from electrical, thermal, and spectroscopic observations that energy can pass from the molecules of a gas to the æther; and we know that when a gas warms its containing vessel or expands against pressure, external work is done by it upon ponderable matter. Now it is very important to observe at the threshold of our inquiry that these are *the only ways* in which any energy whatever is expended by a gas. Retarding forces of one kind or other arise in all the motions with which we are most familiar on the earth, because the motions we are accustomed to take notice of are molar motions of the irrotational type, pursued under such conditions that part of the molar energy is constantly leaking down into subsidiary molecular activities. When, however, we get to the bottom of the series of irrotational motions, beneath which there are none underlying, no such degradation of energy is possible. Accordingly there is absolutely no loss of energy in the encounters between molecules; neither is there a trace of anything like friction or viscosity between the different parts of a molecule to impede any events that may be going on within it during its flight between one encounter and the next. All its internal motions are even more free from any such interference than are the motions of the planets, which are affected, in a minute degree, both by meteors and by tidal actions.

Very striking information about these internal events is furnished by the spectroscope, which reveals to us the fact that they are such as to occasion *definite* undulatory changes in the surrounding æther. Each gas is in fact found to emit an interrupted spectrum, consisting of separated lines; of which the positions, intensities, and general appearance are characteristic of the molecules from which they emanate. We thus become aware of the fact that each gaseous molecule, and as a consequence each chemical atom, is an elaborate system within which highly complex changes of a periodic character are perpetually taking place.

The object of the present communication is to try to cross the threshold of an inquiry as to what these molecular events are.

In this investigation we shall have to treat of periods of time too small to be conveniently spoken of as fractions of a second. And, fortunately, the nature of the subject indicates the best way of dealing with them. This is by making use of the velocity of light and other electro-magnetic waves in the open æther, which

is one of the three fundamental fixed units of nature.* This standard velocity I propose to call the *Maxwell.* It is a velocity of almost exactly 30 quadrants of the earth per second, meaning by a quadrant the distance along the earth's meridian from the equator to the pole—in other words, it is a velocity of 300 millions of metres per second. It is a velocity that pervades all nature and establishes a natural relation, which exists everywhere, between time and length. Accordingly lengths, such as metres, millimetres, &c., do naturally represent definite periods of time, viz. the times occupied by light in advancing over those distances in the open æther. But as perhaps it might be thought too great a departure from usage to speak of metres, millimetres or tenthet-metres† of time, I shall for our present purpose select one definite period, viz. the time that light takes to advance the tenth part of a millimetre, and will call it the *jot* of time. This little fragment of time, which is one-third of the billionth of a second, will be found a very convenient standard in which to measure the periods which present themselves in the study of molecular events. Thus light takes one deka-jot to advance a millimetre; it advances a tenthet-metre in the micro-jot, meaning by the deka-jot, ten jots, and by the micro-jot, the millionth part of a jot. The periodic times of the oscillations that present themselves in the spectra of gases range from a little less than two milli-jots up to about twelve milli-jots, meaning by the milli-jot the thousandth part of a jot. This range extends from the limit in the ultra-violet explored by Professor Hartley to the farthest ultra-red reached by Captain Abney. In ordinary air the flight of a molecule between its encounters lasts on the average about 420 jots,‡ during which time there can, accordingly, take place upwards of 200,000 of the swiftest and 30,000 of the slowest of the oscillations§ spoken of above—oscillations which we must bear in mind are set up in the surrounding æther by the events that occur in the molecules.

* See a Paper by the author in the *Proceedings of the Royal Dublin Society*, February 16, 1881, and in the *Phil. Mag.*, May, 1881, p. 384.

† A tenthet means a unit in the tenth place of decimals; in other words it is $1/10^{10}$.

‡ The rate of diffusion of gases and the amount of their viscosity depend on the length of the excursion of the molecules. Maxwell made three determinations founded on this consideration, the mean of which is that the average length of the free path in air is a little more than seven eighthet-metres ($7/10^8$ of a metre). See *Phil. Mag.* for August, 1868, p. 138, where Maxwell's results are collected. Taking seven eighthet-metres as the length of the excursion, and 500 metres per second (the "velocity of mean squares" in air at 18° temperature) as the speed of the molecule, the mean duration of its flights will be 420 jots. It is probably a little more than this in air, and will vary in different gases and in the same gas under different circumstances; but *for the purposes of this Paper* a very rough approximation is sufficient, and accordingly we shall use 420 jots when we want to indicate the sort of interval of time that elapses while a molecule is on one of its journeys.

§ The word oscillation is used throughout this Paper in a generalized sense to include revolutions in an orbit as well as vibrations in a straight line.

The first step to connect these æthereal oscillations with motions in the molecules was I believe taken by the author when, in 1870, he pointed out the harmonic relation which exists between the lines α, β, and δ of the line spectrum of hydrogen. These are the lines C, F, and h of the solar spectrum. Their periodic times are inversely as the numbers 20 : 27 : 32. This gives evidence that these three lines have their source in some one event in the molecules of hydrogen. The next step was taken by Professor J. Emerson Reynolds and the author working in conjunction in the laboratory of the Royal Dublin Society in 1871, when, on a careful examination of the spectrum of chlorochromic anhydride (CrO_2Cl_2), it was ascertained that the sequence and intensities of a very long series of lines in the absorption spectrum of that ruddy vapour, stand in a close relationship to the sequence and intensities of the series of harmonics emitted by a violin under definite circumstances, viz. when the string is bowed at a point nearly, but not quite, two-fifths of its length from the bridge.* From this, and from the regularity in the spacing of the lines, it appears that all the lines of this long series have their source in some one event occurring in the molecules of the vapour. It was also ascertained by mixing air with the vapour that this event is one which is independent of the encounters that must then occur between molecules of the vapour and molecules of the air. It is therefore probably a periodic event excited and maintained by the incident light during the comparatively long periods of flight of the molecules, which, in the experiments that were made, lasted over some hundreds of jots, and not during the very much briefer periods when the molecules are now and then grappling with one another in struggles, no one of which probably can last more than some very few jots. During these brief encounters we must presume that the motions excited by the incident light are, on the contrary, in part obliterated, since some of the energy which is absorbed from the æther increases the pressure of the vapour.

The next notable event was the discovery by Dr. Huggins, that the four hydrogen lines of the solar spectrum are part of a much longer series of lines arranged in a conspicuous pattern, which is evidence that they are due to some common cause. Dr. Huggins found the additional lines in the spectra of white stars. They are absent from our Sun. This discovery was shortly followed by a laboratory investigation, confirming the opinion suggested by the telescopic observation, viz. that the whole series is due to hydrogen.

Then followed the very important discovery of "Balmer's Law." Professor Balmer, in 1885, showed that the law connecting three of the hydrogen lines, to which the author had called attention in 1870, is part of a more comprehensive law which includes the whole series. This comprehensive law is that

* See *Phil. Mag.* for July, 1871, p. 47.

the oscillation-frequencies of the successive lines is given by the formula

$$N_{m-2} = k\left(1 - \frac{4}{m^2}\right),$$

in which k is a constant for the whole series. By putting, successively, into this formula the whole numbers 3, 4, 5, 6, &c., for m, it furnishes values for N, which are the oscillation-frequencies of the successive lines. This still further establishes the fact that these rays are caused by one event, or by one body of inter-dependent events, occurring in the molecules of the gas. It can easily be seen that the 1st, 2nd, and 4th of this series are $k\frac{20}{36}$, $k\frac{27}{36}$, and $k\frac{32}{36}$, in accordance with the law which I had announced in 1870.

There are many series of lines known to spectroscopists which form patterns somewhat like that of the hydrogen series, and which we may presume are to be referred to some one event or group of associated events occurring in the molecules of the gas. The discovery of Balmer's law has stimulated other inquirers to search for similar simple laws connecting the oscillation-frequencies in cases of this kind; and these attempts have at all events elicited useful approximate laws, which have done science the service of making it possible for the investigator in many important cases to pick out the members of an associated series of lines, where the individual lines are too far separated, or too much mixed up with lines not belonging to the series, for his eye to detect the association upon mere inspection.* Most useful work of this kind has been carried on by Professors Kayser and Runge in Germany and by Professor Rydberg in Sweden. It must suffice here to give an outline of those results of Professor Rydberg's analysis of the spectra of the monads lithium, sodium, potassium, ruthenium, and cæsium, to which a new and special meaning is imparted by the investigation in the present Memoir.

Both Professor Rydberg and Professors Kayser and Runge find† that the spectrum of each of these elements contains and almost altogether consists of three series of double lines. The distribution of the pairs constituting each series over the spectrum is such as to form a pattern somewhat like that of the great hydrogen series to which Balmer's law applies, although no equally simple law has been detected connecting their positions. We shall presently see

* The first work of this kind with which I am acquainted was the successful separation of one of the bands of the spectrum of CO into two distinct series by Professor Alexander Herschel in 1883. See *Transactions R. S. Edinb.*, vol. xxxii., p. 454. It was carried out before the announcement of Balmer's law, by the help of a harmonic law.

† Professor Rydberg, "Recherches sur la Constitution des Spectres d'Émission des Elements Chimiques" (*Transactions of Royal Academy of Sciences of Sweden,* 1889, Bandet 23, No. 11). Professors Kayser and Runge, "Über die Linienspectren der Alkalien" (*Transactions of the Berlin Academy of Sciences,* 1890, St. xxviii., s. 555).

that the oscillations of the lines in these spectra are not quite synchronous with the motions in the molecules that originate them, while in hydrogen, by reason of the extreme closeness of the double lines, they are almost exactly synchronous. It will also be shown how the periodic times of the molecular motions may be deduced from the observations.

Professor Rydberg designates by the letters P, D, and S, the three series of pairs of lines found in the spectrum of each of the foregoing elements: P being what he calls the *principal* series of pairs of lines, D a series of pairs of *diffuse* or nebulous lines, and S a series of pairs of *sharp* lines. All the observations he has been able to collect support the conclusion that the more refrangible line of each pair of the series P is the stronger, while the reverse is the case in the two other series. What this means will appear in the sequel.

Professor Rydberg is of opinion that when the lines are plotted down on a map of oscillation-frequencies, the distance between the two lines of each pair, which we may call Δ, is the same *throughout the whole of each series*, and even in all the three series. It may be doubted whether the observations he has collected are as yet sufficient to give us confidence on this point. It will doubless be settled by the great photographs that Professor Rowland has succeeded in obtaining with his unrivalled apparatus, and which we may hope will soon be published. It may, however, prove to be the case; and we shall see in the following chapters the important meaning which would attach to it.

Finally, Professor Rydberg has ascertained that the value of Δ (the interval between the lines of each pair), while it varies but little between the three series of pairs of lines in each element, differs very much in passing from one element to another: the pairs being closest in lithium, somewhat wider in sodium, wider still in potassium, very wide in rubidium, and widest of all in cæsium. What this means will also be explained.

CHAPTER II.

THE PROBLEM TREATED DYNAMICALLY.

The alternations of electro-magnetic stress in the æther which constitute light form an undulation which is propagated under the same laws as the transverse vibrations of a suitable medium. We shall in the present chapter treat the subject under this purely dynamical hypothesis, and will in the following chapter make those corrections which are required to convert the investigation into one under the electro-magnetic theory of heat and light.

We shall accordingly, for the present, regard certain points in the molecules of the gas as acting dynamically on an æther capable of receiving and transmitting only transverse vibrations, and we have to inquire what motions of these points within the molecules would impart to the medium the oscillations which correspond to the observed lines in the spectrum.

Let us then fix our attention on a particular molecule M, and suppose that a point P in it which acts on the æther has been set moving along some orbit within the molecule by the last of the inter-molecular encounters to which M has been subjected. We are in ignorance as to what the forces are, under the influence of which the point P will continue its motion during the flight of the molecule; but, nevertheless, there is one case which admits of treatment up to a certain point; and on comparing the conclusions of this treatment with the simplest spectra—those of the light monad elements—we find that the conditions which lead to it occur in them. We shall confine our attention in the present Memoir to this case. It presents itself whenever one or some forces acting on P are predominant over all the others, and the treatment to be employed is the same as that with which we are familiar in the lunar and planetary theories. In applying this method the real course of the point P is to be arrived at by first laying down its "dominant orbit," that is the path which P would pursue if the dominant forces were the only ones acting on it, and by then subjecting this orbit to perturbations while P is traversing it. These perturbations are of two kinds:—(1°) such a gradual shifting of the position of the dominant orbit while P is revolving round it, as will bring P at each instant to the real position which it actually does then occupy under the influence of all the forces; accompanied by (2°) such a gradual change of the form of the dominant orbit as may be necessary to render it at each instant the orbit which P would describe if the perturbating forces were then suddenly to cease acting. If the perturbating forces be feeble these changes will be slow as well as

gradual, slow in comparison with the much more rapid motion of P in the dominant orbit, which is going on at the same time.

However complex the dominant orbit may be, it will be shown in Chapter IV. that the motion of P in it is equivalent to the coexistence and superposition of a number of "partials," each of which is a pendulous elliptic motion of P represented by—

$$\left.\begin{aligned} x &= a \cos \theta t, \\ y &= b \sin \theta t, \end{aligned}\right\} \tag{1}$$

a, b and θ being constants which differ in the different partials. θ, which is the angular velocity of the growing angle θt, may also be called the *swiftness* of the *elliptic* motion. It is the same as $2\pi m/j$, where m is the *frequency* of the elliptic revolutions in a jot of time. The *periodic time* is, of course, j/m. The value of m must lie between 80 and 500, whenever the frequency of this elliptic motion is the same as that of any undulation in the æther which can produce a line in the parts of the spectrum that have been explored; and as in ordinary air each molecular journey lasts on the average about 420 jots, there is time for a vast number—say from 35,000 to 210,000—of the revolutions of the point P represented by equations (1) to take place during one flight of the molecule.

If the dominant orbit of P were the real orbit of P, each of its partials would produce a single line in the spectrum. But it is not likely that the motion can go on without its being affected by disturbing forces emanating from other parts of the molecule, or from the æther in its neighbourhood; and so many revolutions of P take place during one of the flights of the molecule that there is abundant time for the operation of these disturbing forces. Now, the investigations that have been made into the perturbations which occur within the solar system enable us to predict at once what kinds of effects such disturbing forces would produce. They are (1°) an apsidal motion of the elliptic partial in its own plane; (2°) a precessional shifting of the line of nodes in which this plane intersects the "invariable plane"; (3°) a periodic change in the inclination of these two planes; (4°) a periodic change of the ellipticity of the partial. All these may be regarded as perturbations of relatively long period, but the conditions within the molecule may be such as to occasion (5°) disturbances of shorter period affecting any one or more of the foregoing, and producing an effect on them somewhat like that of nutation superimposed upon precession. We shall accordingly proceed to inquire how each of the foregoing perturbations would manifest itself in the spectrum.

The first problem of this inquiry only requires to be enunciated. It is—

PROBLEM I.—How will a simple elliptic motion of P in the molecules of the gas, such as that represented by equations (1), manifest itself in the spectrum of the gas?

It will obviously give rise to a single line in the spectrum, whose position on a map of oscillation-frequencies is m, and whose intensity may be represented by $a^2 + b^2$.

PROBLEM II.—How will this simple spectrum be altered if there is an apsidal motion of the ellipse in its own plane?

Draw rectangular axes of co-ordinates from the centre of the ellipse as origin, and at an angle ψt with the axes Ox and Oy of equation (1). Regard the axes OX and OY as fixed, and let $\psi = 2\pi n/j$. The ellipse will then travel round with an apsidal motion such that n is the frequency of the apsidal circuits in one jot of time. The co-ordinates of P referred to the fixed axes are—

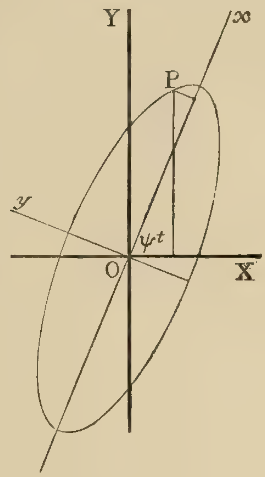


FIG. 1.

$$X = a \cos \theta t \,.\, \cos \psi t - b \sin \theta t \,.\, \sin \psi t;$$

$$Y = a \cos \theta t \,.\, \sin \psi t + b \sin \theta t \,.\, \cos \psi t.$$

equations which are equivalent to

$$\left.\begin{aligned} X &= \frac{a+b}{2} \cos (\theta + \psi) t + \frac{a-b}{2} \cos (\theta - \psi) t; \\ Y &= \frac{a+b}{2} \sin (\theta + \psi) t - \frac{a-b}{2} \sin (\theta - \psi) t. \end{aligned}\right\} \qquad (2)$$

In other words,

$$X = X_1 + X_2,$$

$$Y = Y_1 + Y_2,$$

where

$$\left.\begin{aligned} X_1 &= + \frac{a+b}{2} \,.\, \cos (\theta + \psi) t, \\ Y_1 &= + \frac{a+b}{2} \,.\, \sin (\theta + \psi) t, \end{aligned}\right\} \qquad (3\,a)$$

and

$$\left.\begin{aligned} X_2 &= + \frac{a-b}{2} \,.\, \cos (\theta - \psi) t, \\ Y_2 &= - \frac{a-b}{2} \,.\, \sin (\theta - \psi) t, \end{aligned}\right\} \qquad (3\,b)$$

each of which represents a circular motion. Accordingly an elliptic motion whose frequency is m, when affected by an apsidal perturbation whose frequency is n, is equivalent to the motion of P resulting from the two circular motions represented by equations (3 a) and (3 b). These circular motions are in opposite directions,

their frequencies are $m + n$ and $m - n$, and their radii are $(a + b)/2$ and $(a - b)/2$.

If the molecules of the gas be immersed in an æther such as we have assumed, viz. one susceptible of transverse vibrations only, the foregoing motion will produce two lines in the spectrum whose positions on a map of oscillation-frequencies will be $m + n$ and $m - n$. Moreover, the ratio of the intensities of the two rays propagated in any one direction from the gas through the æther will be the ratio of $(a + b)^2$ to $(a - b)^2$, whether we take into account the contribution from one molecule only, or the combined effect of all the molecules.

We thus find that the *double lines* which are a conspicuous feature of all gaseous spectra, and of which the spectra of the monad elements appear wholly to consist, *are accounted for* by supposing that an apsidal perturbation operating during the journeys of the molecules between their encounters, affects the dominant motion set up in them by the encounters.

The equations hitherto given represent the motion when the apsidal motion is in the same direction as the elliptic, and here the more refrangible line, whose oscillation frequency is $m + n$, is the brighter. If, however, the perturbating forces are such that the apsidal motion takes place in the opposite direction to the revolution of P in its ellipse, we must change the sign of ψ in all the equations; from which it appears that it is now the less refrangible line which is the brighter. If any of the elliptic partials should chance to be a circle, $b = a$, and one constituent of the double line is of cypher intensity. Accordingly, the other alone will present itself in the spectrum, and will have in it the position $m + n$ when the circular motion and the apsidal are in the same direction, and the position $m - n$ when they are in opposite directions. And, finally, whenever the partial of the dominant motion represented by equations (1) is a mere vibration in a straight line instead of a revolution in an ellipse, b, the axis minor, vanishes, and the intensities of the spectral lines (which are always to one another in the ratio of $(a + b)^2$ to $(a - b)^2$) become equal.

The following figures represent the several cases which have been considered. All of them are met with in the actual spectra of gases.

FIG. 2 (a).—Spectrum of one of the partials of the dominant motion of P, viz. of a pendulous elliptic revolution of P in the molecules of the gas such as that represented by equations (1).

FIG. 2 (b).—The double line into which this resolves itself when the elliptic motion in the molecules is affected by an apsidal motion in the same direction as the elliptic motion. In this case the more refrangible line is the stronger. See equations (3 a) and (3 b).

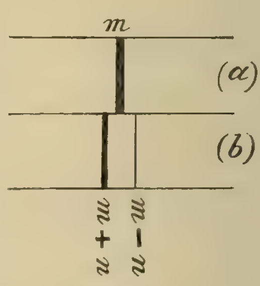


FIG. 2.

Fig. 3 (a).—Simple elliptic motion as before.

Fig. 3 (b).—The double line when the apsidal motion is in the opposite direction to the elliptic motion. Here the less refrangible line is the stronger. This case is represented by changing the sign of ψ in equations (3 a) and (3 b).

Fig. 4 (a).—Spectrum of a simple circular partial. This case is represented by making $b = a$.

Fig. 4 (b).—Position to which this line is shifted when there is apsidal motion in the same direction.

Fig. 5 (a).—Spectrum of a circular partial as before.

Fig. 5 (b).—Position to which the line is shifted when there is apsidal motion in the opposite direction.

Fig. 6 (a).—Spectrum of a pendulous vibration in a straight line. This case is represented by making $b = 0$ in equations (1).

Fig. 6 (b).—The spectrum of this vibration subjected to apsidal motion. Here the constituents of the double line are equally strong. This case is represented by putting $b = 0$ in equations (3 a) and (3 b).

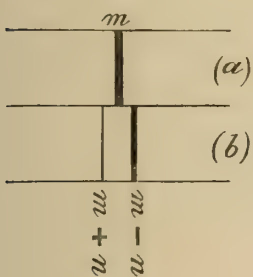


Fig. 3.

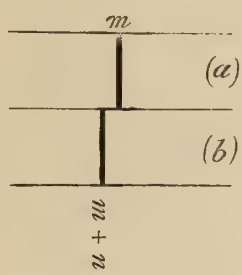


Fig. 4.

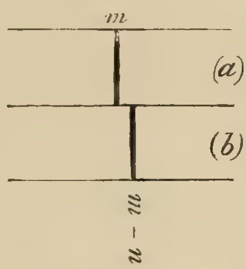


Fig. 5.

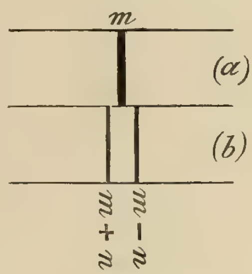


Fig. 6.

Precessional Motion.—Both the revolution of P in the elliptic partial and the apsidal rotation of the ellipse, if not subjected to further disturbance, take place in a fixed plane; but unless special conditions are fulfilled within the molecules the perturbations will be such that this plane will shift its position in relation to the "invariable plane." To represent this motion let us conceive an axis perpendicular to the invariable plane and passing through the centre of the ellipse. This axis is called the invariable line. It will in general be oblique to the plane of the ellipse, and we are to suppose the plane of the ellipse to rotate round it while maintaining its inclination to it unchanged. Hence arises—

Problem III.—What change of the spectrum will result from a precessional rotation round the invariable line, of the plane in which the elliptic and apsidal motions take place?

Let us speak of the moving plane (the plane in which the elliptic and apsidal motions take place) as plane B; and let the invariable plane be called plane A.

The invariable line is a fixed line perpendicular to plane A, round which plane B is to be regarded as rotating with a swiftness $\omega = 2\pi k/j$, in which k is the frequency of this motion.

The apsidal motion has already resolved the original elliptic motion into two circular motions in plane B, viz.,

$$\left.\begin{aligned} X_1 &= +\ s \cos St, \\ Y_1 &= +\ s \sin St, \end{aligned}\right\} \tag{4 a}$$

and

$$\left.\begin{aligned} X_2 &= + d \cos Dt, \\ Y_2 &= - d \sin Dt, \end{aligned}\right\} \tag{4 b}$$

which are the same as equations (3 a) and (3 b) when for brevity we write s and d for $(a + b)/2$ and $(a - b)/2$, and S and D for $\theta + \psi$, and $\theta - \psi$.

Draw three fixed axes: Oz along the invariable line, Ox along the direction at which the intersection of planes A and B arrives at the instant t, and Oy perpendicular to Ox in plane A. Then if α be the angle between the planes A and B, equations (4 a) furnish

$$x = s \cos St \tag{5 a}$$

along the intersection of planes A and B at the instant t,

$$y = s \sin St. \cos \alpha \tag{5 b}$$

along a line in plane A which is perpendicular to the intersection of A and B at the instant t, and

$$z = s \sin St. \sin \alpha \tag{5 c}$$

along the invariable line.

Equations (5 a) and (5 b) are an elliptic motion of P in plane A, and when affected by the precessional motion ωt (where $\omega = 2\pi k/j$), furnish the circular motions

$$\left.\begin{aligned} \overline{X}_1 &= + s \cos^2 \frac{\alpha}{2} . \cos (S + \omega)t \\ \overline{Y}_1 &= + s \cos^2 \frac{\alpha}{2} . \sin (S + \omega)t \end{aligned}\right\}, \tag{6 a}$$

and

$$\left.\begin{aligned} \overline{X}_2 &= + s \sin^2 \frac{\alpha}{2} . \cos (S - \omega)t \\ \overline{Y}_2 &= - s \sin^2 \frac{\alpha}{2} . \sin (S - \omega)t \end{aligned}\right\}, \tag{6 b}$$

equations (5 c), (6 a), and (6 b) represent the whole effect; (5 c) is a rectilinear vibration of P perpendicular to the invariable plane, and (6 a) and (6 b) are two

circular motions of P in that plane. These will give rise to three lines in the spectrum, of which the positions on a map of oscillation-frequencies will be

$$\left.\begin{aligned} &m+n+k, \text{ position of } (6\,a) \\ &m+n-k, \quad . \quad . \quad . \quad . \quad (6\,b) \\ \text{and} \qquad &m+n \quad , \quad . \quad . \quad . \quad . \quad (5\,c) \end{aligned}\right\}, \tag{7}$$

with intensities proportional to

$$\left.\begin{aligned} &2s^2 \cos^4 \frac{\alpha}{2}, \text{ intensity of } (6\,a) \\ &2s^2 \sin^4 \frac{\alpha}{2}, \quad . \quad . \quad . \quad . \quad (6\,b) \\ &4s^2 \sin^2 \frac{\alpha}{2}, \cos^2 \frac{\alpha}{2} \quad . \quad (5\,c) \end{aligned}\right\}. \tag{8}$$

If α is small, *i.e.* if the plane of the elliptic motion is nearly coincident with the invariable plane, as it probably is in the molecules of the monad elements H, Li, Na, Rb, Cs. then the line $(6\,a)$ is strong, $(5\,c)$ is faint, and $(6\,b)$ is excessively faint.

The foregoing investigation traces what becomes of the circular motion $(4\,a)$ when affected by precession. A similar treatment of $(4\,b)$ is made by substituting d for s and $-D$ for S. We thus obtain the following :—

$$\left.\begin{aligned} X_1 &= +d \cos^2 \frac{\alpha}{2} \cos (D-\omega)\,t \\ Y_1 &= -d \cos^2 \frac{\alpha}{2} \sin (D-\omega)\,t \end{aligned}\right\}, \tag{9 a}$$

$$\left.\begin{aligned} X_2 &= +d \sin^2 \frac{\alpha}{2} \cos (D+\omega)\,t \\ Y_2 &= +d \sin^2 \frac{\alpha}{2} \sin (D+\omega)\,t \end{aligned}\right\}, \tag{9 b}$$

and

$$z = -2d \sin \frac{\alpha}{2} \cos \frac{\alpha}{2} \sin Dt, \tag{10}$$

producing three lines in the spectrum in the positions

$$\left.\begin{aligned} &m-n-k, \text{ position of } (9\,a) \\ &m-n+k, \quad . \quad . \quad . \quad . \quad (9\,b) \\ &m-n \quad , \quad . \quad . \quad . \quad . \quad (10) \end{aligned}\right\}, \tag{11}$$

with the intensities

$$\left.\begin{array}{ll} 2d^2 \cos^4 \frac{\alpha}{2}, & \text{intensity of } (9\,a) \\ 2d^2 \sin^4 \frac{\alpha}{2}, & \quad \ldots \ldots (9\,b) \\ 4d^2 \sin^2 \frac{\alpha}{2} \cos^2 \frac{\alpha}{2}, & \quad \ldots \ldots (10) \end{array}\right\} \qquad (12)$$

of which (when α is small) the first is strong, the third faint, and the second excessively faint.

Hence when one of the elliptic partials of the dominant motion of P is affected by both apsidal motion and precession, we shall have an appearance in the spectrum which may be represented diagrammatically by the following figures: where (*a*) in each figure represents the spectrum of the original elliptic partial if undisturbed, (*b*) what it becomes when there is apsidal motion, and (*c*) what it becomes when there are both apsidal motion and precession.

All the figures are drawn to represent the state of affairs which is probably what prevails in the monad elements, viz. apsidal and precessional motions, which are slow in comparison with the revolution of P in the elliptic partials of its dominant motion. In this case n and k are small in comparison with m. The three motions may be in the same direction, or one of them in the opposite direction to the other two. Hence arise four varieties.

Variety 1.—The elliptic, apsidal, and precessional motions in the same direction. Here m, n, and k are all positive, and the resulting spectrum may be represented diagrammatically by fig. 7 (*c*), and consists of a pair of lines with satellites inside, the more refrangible group being the brighter.

Variety 2.—The precessional motion in the opposite direction to the other two: m and n are positive, and k negative.

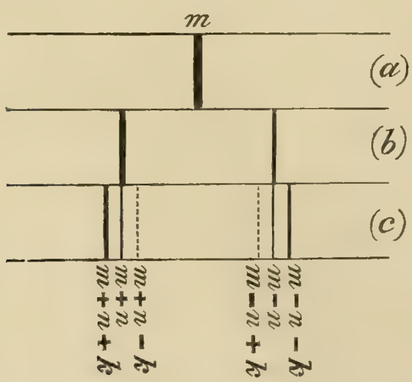


FIG. 7.

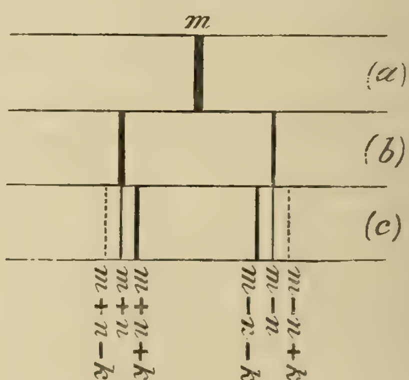


FIG. 8.

FIG. 8 (*c*) represents the spectrum: a pair, of which the more refrangible is the brighter, with satellites outside.

Variety 3.—The apsidal motion opposite the other two. Therefore m is positive, n negative, and k positive.

FIG 9 (c) represents the spectrum: a pair, with satellites outside, the less refrangible group the brighter.

Variety 4.—The fourth variety is when both the apsidal and precessional motions are in the opposite direction to the elliptic. Here m is positive, and n and k are negative, and the spectrum is represented by fig. 10 (c): a pair, with satellites inside, the less refrangible group the brighter.

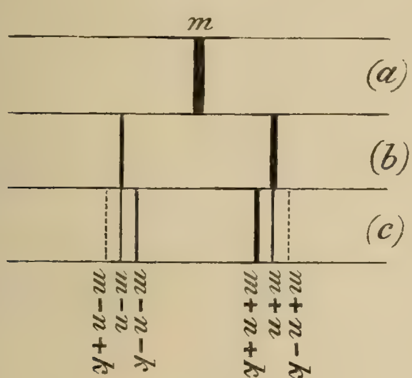


FIG. 9.

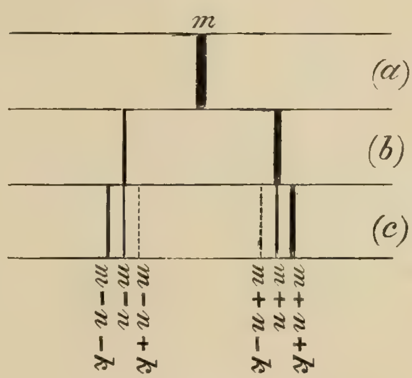


FIG. 10.

These diagrams represent what occurs when the apsidal and precessional perturbations are slow compared with the original orbital motion aroused by the last encounter of the molecule with another molecule. In this case the satellites lie, as in the diagrams, on opposite sides of their primaries, and the primaries themselves have been displaced in opposite directions by the precessional motion.

If, however, the apsidal motion be swift, the orbital motion must be slow to account for the close double lines that are seen in the spectrum. Such relative swiftness of the apsidal motion seems unlikely, and accordingly I will not pursue the supposition further than to remark that if it prevails in any gas the satellites of both components of a double line will lie on the same side of their primaries, *i.e.* either all to the right or all to the left; and the primaries themselves will be displaced in the same, instead of in the opposite directions, by precession.

Corollary.—If there be precessional motion of an elliptic partial without apsidal motion, there will be three equidistant lines in its spectrum, of which the intensities could be computed if a, b, α and β were known, β being the angle between the axis major of the ellipse, and the line in which the plane of the ellipse intersects the invariable plane. For the converse problem, we can observe the intensities of the three lines, and their interval. These will determine the value of k, and will furnish three equations between a, b, α and β, but will not fully

determine these latter. The middle line has the position which would be occupied if there were no precessional motion.

The next matter to be considered is the effect of a periodic change in the inclination of the two planes. Hence—

PROBLEM IV.—In what way will the spectrum of the gas be affected if there be a periodic change in the inclination of the plane of the ellipse to the invariable plane?

This problem is to be investigated exactly in the same way as Problem VI., which is dealt with a few pages farther on. Since the angle α in equations ($5c$), ($6a$), and ($6b$) undergoes a periodic fluctuation, we are to write $(g+h\sin\eta t)$ instead of α in those equations, g, h, and η being constants. If after making this substitution we apply to the equations the same method of treatment as in Problem VI., we shall find that the effect of the perturbation is to render the lines winged.

PROBLEM V.—What effect on the spectrum will a periodic change of ellipticity have?

The change of ellipticity may take place in either of two ways: in one the orbit will pass through a rectilinear form; in the other it will pass through a circular form.

I.—To represent a change of the first kind we must substitute for a and b of equations (1) the following:—

$$(r \cos \epsilon t) \text{ for } a,$$

$$(r \sin \epsilon t) \text{ for } b,$$

where $\epsilon = 2\pi e/j$, e being the frequency of the periodic change of ellipticity. We thus get instead of equations (1)

$$x = r \,.\, \cos \epsilon t \,.\, \cos \theta t,$$

$$y = r \,.\, \sin \epsilon t \,.\, \sin \theta t,$$

which treated as in Problem II. give

$$x = \frac{r}{2}\left[\cos(\theta-\epsilon)\,t + \cos(\theta+\epsilon)\,t\right],$$

$$y = \frac{r}{2}\left[\cos(\theta-\epsilon)\,t - \cos(\theta+\epsilon)\,t\right].$$

These equations represent two rectilinear motions at right angles to one another, of frequencies $m+e$ and $m-e$, and of equal intensity. They, accordingly, would give rise to *a pair of equal lines* in the spectrum of the gas. If there be absidal motion also, each of these will be doubled, and *two pairs* of equal lines will present themselves.

II.—To represent a periodic change of ellipticity, in which the orbit passes through a circular form, we must substitute in equations (1)

$$(r + \rho \cos \epsilon t) \text{ for } a,$$

$$(r - \rho \cos \epsilon t) \text{ for } b,$$

where $\epsilon = 2\pi e/\tau$. We thus obtain

$$x = (r + \rho \cos \epsilon t) \cos \theta t,$$

$$y = (r - \rho \cos \epsilon t) \sin \theta t,$$

which are equivalent to

$$x = r \cos \theta t + \frac{\rho}{2} \cos (\theta + \epsilon) t + \frac{\rho}{2} \cos (\theta - \epsilon) t,$$

$$y = r \sin \theta t - \frac{\rho}{2} \sin (\theta + \epsilon) t - \frac{\rho}{2} \sin (\theta - \epsilon) t.$$

This motion, if ρ is small, produces *a line at frequency* m, *with two equal satellites at frequencies* $m + e$ *and* $m - e$, i.e. *one on either side of the primary.*

Another perturbation which may possibly present itself would consist in the alternate contraction and dilatation of the ellipse. This is represented by the equations

$$\left.\begin{aligned} x &= a \,.\, \cos \epsilon t \,.\, \cos \theta t, \\ y &= b \,.\, \cos \epsilon t \,.\, \sin \theta t, \end{aligned}\right\} \qquad (13\,a)$$

where $\theta = 2\pi m/j$ and $\epsilon = 2\pi e/j$. The energy of this motion is $(a^2 + b^2)/2$, if we represent the energy of the simple elliptic motion of equations (1) by $a^2 + b^2$.

PROBLEM VI.—What appearance in the spectrum would this perturbation occasion: 1°, if alone; 2°, if accompanied by an apsidal shifting of the ellipse?

1°. Equations (13 a) are equivalent to

$$\left.\begin{aligned} x &= \frac{a}{2} \,.\, \cos (\theta + \epsilon) t + \frac{a}{2} \cos (\theta - \epsilon) t, \\ y &= \frac{b}{2} \,.\, \sin (\theta + \epsilon) t + \frac{b}{2} \sin (\theta - \epsilon) t. \end{aligned}\right\} \qquad (13\,b)$$

Hence the perturbation, when alone, occasions two equal lines of intensity $(a^2 + b^2)/4$, at the positions $m + e$ and $m - e$ on a map of oscillation-frequencies.

2°. Equations (13 b) are equivalent to

$$x = x_1 + x_2,$$

$$y = y_1 + y_2,$$

where

$$\left.\begin{aligned} x_1 &= \frac{a}{2} \cos St \\ y_1 &= \frac{b}{2} \sin St \end{aligned}\right\} \text{ and } \left\{\begin{aligned} x_2 &= \frac{a}{2} \cos Dt, \\ y_2 &= \frac{b}{2} \sin Dt. \end{aligned}\right.$$

Let the system which is equivalent to the coexistence of motion in these two orbits undergo an apsidal shift, the frequency of which is n. Then, proceeding as in Prop. II., we find that each of the two orbits gives rise to a double line. We thus get four lines at the positions and with the intensities.

POSITIONS.	INTENSITIES.	
$m + e + n$	$(a + b)^2/8$	equal.
$m - e + n$	$(a + b)^2/8$	
$m + e - n$	$(a - b)^2/8$	equal.
$m - e - n$	$(a - b)^2/8$	

Hence when the perturbation is accompanied by apsidal motion there will be four lines, which will appear in the spectrum, as in (a) or (b) of fig. 11, if e is greater than n; and as in (a) or (b) of fig. 12, if e is less than n.

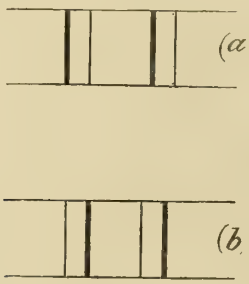


FIG. 11.

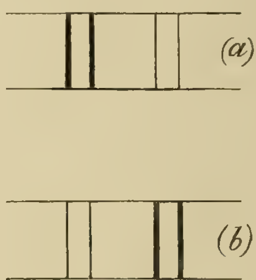


FIG. 12.

It remains to consider what appearance in the spectrum would present itself if there be a periodic oscillation in any of these perturbations, such as nutation produces on the precessional motion of the earth. Let us—to take one instance—suppose that the apsidal motion is affected in this way. Then—

PROBLEM VII.—If there be a periodic oscillation in the apsidal motion, what effect will this have on the spectrum ?

To represent such an oscillation we must write

$$(\psi t + a \sin \zeta t) \text{ instead of } \psi t$$

in the equations of Problem II., where

$$\psi = 2\pi n/j \text{ and } \zeta = 2\pi q/j.$$

This substitution being made in any of the equations of Problem II., suppose in equations (3 a), we get

$$\left.\begin{aligned} X_1 &= \frac{a+b}{2} \cos\left[(\theta+\psi)t + \alpha \sin \zeta t\right], \\ Y_1 &= \frac{a+b}{2} \sin\left[(\theta+\psi)t + \alpha \sin \zeta t\right]. \end{aligned}\right\} \qquad (14)$$

To see how this will operate, imagine β to be the value through which ζt passes at the instant when $t = \tau$. Then for a short period of time after

$$\sin \zeta t = \sin \beta + \cos \beta \,.\, d \,.\, \zeta t$$

$$= \sin \beta + \cos \beta \,.\, 2\pi \frac{q}{j}\, dt,$$

in which dt is to be regarded as equal to $t - \tau$ for a short time after the epoch τ. Putting this into (14) we find that equations (14) during a short period furnish a line of frequency $(m + n + \alpha \cos \beta \,.\, q)$. By dividing j/q the periodic time of ζt, into equal parts; by giving to a series of β's the values which ζt has at the commencement of each of these equal intervals of time; and by then supposing that the duration of these intervals decreases while their number increases indefinitely: we find that the total effect is the limit (when N increases indefinitely) of a band of N lines of equal brightness, crowded towards the middle, and becoming more and more spaced asunder towards the edge—in other words, it is a nebulous or 'diffuse' line fading out equally* on both sides. The middle of the line has the frequency $m + n$, and its wings extend from $m + n + \alpha q$ on the more refrangible side, to $m + n - \alpha q$ on the less refrangible side.

The same appearance in the spectrum would result from a periodic oscillation affecting either of the other perturbations; and in Problem IV. we have found that wings will present themselves if there is a fluctuation in the inclination of the plane of the ellipse to the invariable plane. Accordingly, nutation makes the lines diffuse, and a fluctuating inclination makes them winged.

* That is, equally, if the nutation is a mere pendulous one.

CHAPTER III.

THE PROBLEM TREATED FROM THE STANDPOINT OF THE ELECTRO-MAGNETIC THEORY OF LIGHT.

Whether we proceed under the crude dynamical hypothesis which we have hitherto adopted, or under the electro-magnetic theory to which we are now to direct our attention, we must distinguish between the motions of or in the molecules which do not affect the luminiferous æther, and certain others which set up an undulation in it—an undulation which consists of transverse oscillations under the dynamical hypothesis, but of alternations of electro-magnetic stresses under the electro-magnetic theory. Among motions of the first kind, those that do not affect the æther and are not affected by it, we are to include the following: the progressive journeys of the molecules as they dart about between the encounters; the much swifter translation which carries a molecule of the gas through the æther at the rate of 30,000 metres per second, in common with the rest of the earth; and other motions of a like kind. There are also probably motions in the molecule of a swiftly periodic kind that do not affect the æther, but there are certainly some that do, and it is these that we have to investigate.

The simplest hypothesis for our purpose is to disregard the motion of the molecule through the æther, whether that which it has in common with the earth, or that which is peculiar to it, such as its darting about in the gas. We may simplify the problem by disregarding these, and may treat the molecule as though it remained at one station in the æther, undergoing internal periodic motions, some of which are of parts that carry charges of electricity with them, and, therefore, act on the æther and are acted on by it; so that periodic motions, when set up in these parts, will cause a synchronous motion in the æther. Correspondingly, an undulation in the æther of suitable periodic time will set these parts of the molecule in motion, and through them, perhaps other parts of the molecule. The distinction between the motions which do, and the motions which do not, affect the æther, requires to be taken into account equally on the dynamical hypothesis and on the electro-magnetic theory.

To pass from the dynamical investigation to the electro-magnetic, attention must be given to Faraday's "Law of Electrolysis," which is equivalent to the statement that in electrolysis a definite quantity of electricity, the same in all cases, passes for each chemical bond that is ruptured. The author called attention to this form of the Law in a communication made to the British Association in

1874, and printed in the *Scientific Proceedings* of the Royal Dublin Society of February, 1881, and in the *Philosophical Magazine* for May, 1881 (see pp. 385 and 386 of the latter). It is there shown that the amount of this very remarkable quantity of electricity is about the twentiethet (that is, $1/10^{20}$) of the usual electro-magnetic unit of electricity, *i.e.* the unit of the ohm series. This is the same as three-eleventhets ($3/10^{11}$) of the much smaller *C.G.S.* electrostatic unit of quantity. A charge of this amount is associated in the chemical atom with each bond. There may accordingly be several such charges in one chemical atom, and there appear to be at least two in each atom. These charges, which it will be convenient to call *electrons*, cannot be removed from the atom; but they become disguised when atoms chemically unite. If an electron be lodged at the point P of the molecule, which undergoes the motion described in the last chapter, the revolution of this charge will cause an electro-magnetic undulation in the surrounding æther. The only change that has to be made in our investigation to adapt it to this state of things is to change θt into $(\theta t - \pi/2)$, *i.e.* a mere change of phase. We, in this way, represent the fact that it is the tangential direction and velocity of the motion of P, not the direction and length of its radius vector, which determine the direction and intensity of the electro-magnetic stresses in the surrounding æther. We have further to correct for the change of phase (about one-fourth of a vibration period) consequent upon what takes place in the immediate vicinity of the moving charge.

Within the molecule itself the oscillation of the permanent charge probably causes electric displacements in other parts of the molecule; and it is possible that it is to the reaction of these upon the oscillating charge that we are to attribute those perturbations of which the double lines in the spectrum give evidence. They obviously may, however, have some other source.

Beside the irremoveable electric charges which electrolysis has brought to light, and which establish the fact that some parts of the molecule behave as perfect non-conductors, there may presumably be temporary charges in such other parts of the molecule as conduct. This probably happens by direct electrification of the molecule when the luminous condition of the gas is produced by the passage of an electric current through it, and it would seem that it must also be brought about indirectly in cases of combustion, owing to the combinations and decompositions which then occur during which some of the permanent charges become disguised or cease to be disguised; in either case having the effect of charging the molecule with free electricity, positive or negative.

Now, molecules whether electrified in these ways, or by the motions set up within the molecule developing electricity as in an influence machine, must be expected to discharge into one another when they collide, and hence will arise

the kind of undulation in the æther which is exhibited in Hertz's experiments. The periodic time of this undulation is, as is known,

$$T = 2\pi\sqrt{IS} \,.\, \sec\rho,$$

where

$$\sin\rho = \frac{R^2 S}{4I},$$

S being the capacity of the molecule, I the co-efficient of self-induction in the current, and R its resistance. It is doubtful whether S, I, and R can be such as will bring the periodic time low enough to correspond to that of any of the observed lines; and even if this be the case, the discharge would probably produce only a single line in the spectrum, or a line and its harmonics. The presence of double lines affords further evidence that the observed spectrum does not arise from these Hertzian discharges, since they require as their cause some event affecting the lines which operates with a sameness in all the molecules which, we may presume, is inconsistent with the chance conditions under which discharges between molecules would take place. But the most conclusive evidence on this point is furnished by the reversal of the lines of incandescent gases when surrounded by their own vapour at a lower temperature. This phenomenon shows that the undulation created in the æther by one set of molecules is capable of effacing itself by transferring back the energy of its special oscillations to another set of the molecules that are more quiescent. This seems incompatible with the event being a Hertzian discharge between pairs of molecules, since this is not a process which would be reversed under the conditions supposed, while it does *exactly* agree with what would appear to be inevitable if the event is the movement of an electron in that orbit which is its natural swing.

To explain, therefore, the lines that present themselves in the spectra of incandescent gases, it is probable that we must fall back upon the motions communicated by the encounters to those non-conducting parts of the molecule in which are lodged the electrons, and upon periodic changes in the distribution of electricity in the conducting part of the molecule consequent upon the movements of these permanent charges. These will be synchronous, and will jointly excite an electro-magnetic undulation in the æther with the periodic times that they have in common.

There seems but one other point in this connexion that needs elucidation. It may be thought that with a multitude of molecules, each oscillating within itself, the external effect will be *nil*—that every molecule in which the point P moves one way, will be counteracted by some other molecule, in which the point P moves the opposite way. But this is to overlook the fact that, in addition

to molecules acting on the æther, the æther reacts on them; and thus each molecule is indirectly influenced through the æther by all its neighbours, whereby the direction and phase of its oscillations will inevitably fall into a sufficient accordance with theirs.

We may therefore freely use the whole of the investigation in the last chapter to represent what takes place under the electro-magnetic theory of light; merely remembering that θt is now a quadrant in advance of where it was under the dynamical hypothesis, so that to represent the position of the point P we must substitute $(\theta t - \pi/2)$ for θt in all the equations of Chapter II. This, in no respect, affects any of the conclusions.

CHAPTER IV.

ANALYSIS BY FOURIER'S THEOREM.

We have hitherto treated in detail only those cases (if any such occur) in which the original motion of the electron, set up by the encounter, is a pendulous elliptic motion. But this degree of simplicity is not met with in any known spectrum. The line spectrum of hydrogen is the least complex with which we are acquainted, and the next in simplicity are the spectra of the other light monad elements, lithium, sodium, potassium, rubidium, and cæsium. In the spectrum of hydrogen there is at all events one great series of lines (probably double lines), and in the spectrum of each of the others three such series are known. It becomes therefore of importance to inquire whether the entire of one of these series of lines emanates from the motion of *one* of the electric charges in the molecules of the gas. The following propositions, in conjunction with what has been done in the preceding chapters, lay much of the foundation for following up this inquiry.

However complex the motion of a point may be, provided it takes place in a straight line, Fourier's theorem resolves it into pendulous elements. This is enough for the purposes of acoustics, inasmuch as the motions to be dealt with in that science are sensibly rectilinear. But it is not sufficient when dealing with the transmission of electro-magnetic stresses through the æther, since the alternations of such stresses are propagated under the laws of an undulation in which the motion of each point is restricted, not to a line but to a plane. Hence arises—

PROBLEM A.—What theorem corresponds to Fourier's theorem when the motion takes place along any *plane* curve?

Here the motion is represented by

$$\left.\begin{aligned} x &= F_1(t), \\ y &= F_2(t), \end{aligned}\right\} \qquad (a)$$

where F_1 and F_2 may be any two functions. By Fourier's theorem, these become

$$\left.\begin{aligned} x = A_0 &+ A_1 \cos \theta_1 t + A_2 \cos \theta_2 t + \ldots \\ &+ B_1 \sin \theta_1 t + B_2 \sin \theta_2 t + \ldots \\ y = C_0 &+ C_1 \cos \theta_1 t + C_2 \cos \theta_2 t + \ldots \\ &+ D_1 \sin \theta_1 t + D_2 \sin \theta_2 t + \ldots \end{aligned}\right\}, \qquad (b)$$

where $\theta_1 = 2\pi m_1/T$, $\theta_2 = 2\pi m_2/T$, &c., in which $m_1\, m_2$, &c., are positive integers when T is the periodic time (if any) of the motion, and in which $m_1\, m_2$, &c., are numbers of which some at least are fractions when T is not the periodic time. If the motion resolves itself into a finite number of terms, and if it is at the same time one which does not repeat itself in a period however long, some of the numbers $m_1\, m_2$, &c., are incommensurable. The coefficients (the A's, B's, C's, and D's), are in all cases represented by the well-known definite integrals of Fourier's theorem, and in some cases calculable from them. It should be borne in mind that a resolution effected by Fourier's theorem is unique: in every case one such resolution exists, and only one.

We shall now proceed to prove that the four terms in these series which stand in any one of the vertical columns of equations (b) represent a pendulous elliptic motion; so that equations (b) in effect resolve the original motion of equations (a), whatever be its law, into partials, each of which is a pendulous elliptic motion.

Take any vertical column, *e.g.* the k^{th}—

$$\left.\begin{aligned} x_k &= A_k \cos \theta_k t \\ &\quad + B_k \sin \theta_k t, \\ y_k &= C_k \cos \theta_k t \\ &\quad + D_k \sin \theta_x t, \end{aligned}\right\} \qquad (c)$$

or, leaving the suffixes to be understood,

$$\left.\begin{aligned} x &= A \cos \theta t + B \sin \theta t, \\ y &= C \cos \theta t + D \sin \theta t, \end{aligned}\right\} \qquad (c^1)$$

and let us try whether we can identify it with the pendulous elliptic motion

$$\left.\begin{aligned} x' &= a \cos (\theta t + \alpha), \\ y' &= b \sin (\theta t + \alpha), \end{aligned}\right\} \qquad (d)$$

in the same plane, and of the same frequency.

Let β be the angle between the axes Ox and Ox'. Then the motion (d) referred to the axes Ox and Oy becomes

$$X = a \cos(\theta t + \alpha) \cos\beta - b \sin(\theta t + \alpha) \sin\beta,$$

$$Y = a \cos(\theta t + \alpha) \sin\beta + b \sin(\theta t + \alpha) \cos\beta,$$

which when expanded becomes

$$\left.\begin{aligned} X &= \cos\theta t\,(a \cos\alpha \cos\beta - b \sin\alpha \sin\beta) \\ &\quad - \sin\theta t\,(a \sin\alpha \cos\beta + b \cos\alpha \sin\beta), \\ Y &= \cos\theta t\,(a \cos\alpha \sin\beta + b \sin\alpha \cos\beta) \\ &\quad - \sin\theta t\,(a \sin\alpha \sin\beta - b \sin\alpha \cos\beta). \end{aligned}\right\} \qquad (e)$$

Now, we can determine a, b, α and β, so as to make

$$\left.\begin{aligned} a \cos\alpha \cos\beta - b \sin\alpha \sin\beta &= +A, \\ a \sin\alpha \cos\beta + b \cos\alpha \sin\beta &= -B, \\ a \cos\alpha \sin\beta + b \sin\alpha \cos\beta &= +C, \\ a \sin\alpha \sin\beta - b \cos\alpha \cos\beta &= -D. \end{aligned}\right\} \qquad (f)$$

Hence, when a, b, α and β, have the values so determined, the pendulous motion represented by (d) is identical with the motion represented by (c^1).

Hence the theorem corresponding to Fourier's theorem is—

THEOREM A.—Any motion of a point in a plane may be regarded as the coexistence and superposition of definite partials which are the pendulous elliptic motions determined as above, one from each of the several vertical columns of equations (b).

These elliptic partials will all be in the plane of the original motion. They will, however, in general lie in different azimuths in that plane, and be in different phases at any one time.*

What lends importance to this theorem is that the resolution effected by it in our calculations is identical with that which an undulation of electro-magnetic stresses in the open æther (as, for example, the great complex undulation which reaches our atmosphere from the sun or a star) does actually undergo when the

* In order to characterize the kind of motion which takes place in a partial, it is sufficient to determine three constants, viz. a, b, and θ (the axes of the ellipse and the swiftness of the motion in it). But to determine the position of P at each instant, it is necessary to determine two more constants β and α (β, the azimuth of the ellipse in its plane, and α the position of P in it at the instant $t = 0$).

A continuous spectrum arises when the θ's of the partials are indefinitely close, a spectrum of lines when they are at intervals that can be perceived.

undulation either advances into a dispersing medium, or suffers diffraction. In the open æther the pendulous elliptic components travel at the same rate and keep together, but on entering a dispersing medium they advance with different speeds and become separated, or, if they encounter a diffraction grating they are by it sent in different directions. It is one or other of these separations that the spectroscope makes manifest to us.

But the motions of the electrons, the electric charges in the molecules of the gases, which are what excite this æthereal undulation, may be motions that are not confined to one plane. Accordingly, to study them, we must investigate—

PROBLEM B.—What theorem corresponds to Fourier's theorem when the motion takes place *along a line of double curvature*?

Such a motion is in general represented by—

$$\left.\begin{aligned} x &= F_1(t), \\ y &= F_2(t), \\ z &= F_3(t). \end{aligned}\right\} \qquad (a_1)$$

When referred to the rectangular axes Ox, Oy, Oz. These when expanded by Fourier's theorem become—

$$\left.\begin{aligned} x = A_0 + A_1 \cos\theta_1 t + A_2 \cos\theta_2 t + \ldots \\ + A'_1 \sin\theta_1 t + A'_2 \sin\theta_2 t + \ldots \\ y = B_0 + B_1 \cos\theta_1 t + B_2 \cos\theta_2 t + \ldots \\ + B'_1 \sin\theta_1 t + B'_2 \sin\theta_2 t + \ldots \\ z = C_0 + C_1 \cos\theta_1 t + C_2 \cos\theta_2 t + \ldots \\ + C'_1 \sin\theta_1 t + C'_2 \sin\theta_2 t + \ldots \end{aligned}\right\}. \qquad (a_2)$$

Let us take any vertical column from these, *e. g.*

$$\left.\begin{aligned} x_k &= A_k \cos\theta_k t + A'_k \sin\theta_k t, \\ y_k &= B_k \cos\theta_k t + B'_k \sin\theta_k t, \\ z_k &= C_k \cos\theta_k t + C'_k \sin\theta_k t, \end{aligned}\right\} \qquad (b_1)$$

or, leaving the suffixes to be understood,

$$\left.\begin{aligned} x &= A \cos\theta t + A' \sin\theta t, \\ y &= B \cos\theta t + B' \sin\theta t, \\ z &= C \cos\theta t + C' \sin\theta t, \end{aligned}\right\} \qquad (b_2)$$

of which (by Problem A) the first two are equivalent to the elliptic motion,

$$x' = u\cos(\theta t + \epsilon),$$
$$y' = v\sin(\theta t + \epsilon),$$

in the plane of xy, and with its axis major inclined at an angle ζ to Ox: u, v, ϵ, and ζ being determined in the same way as a, b, α and β in Problem A.

Thus, taking Ox', Oy', and Oz as axes, we find the motion represented by

$$\left.\begin{aligned} x' &= u\cos(\theta t+\epsilon), \\ y' &= v\sin(\theta t+\epsilon), \\ z &= C\cos\theta t + C'\sin\theta t. \end{aligned}\right\} \qquad (b_3)$$

Let us, by equating coefficients of $\cos\theta t$ and of $\sin\theta t$, determine M and N, such that

$$C\cos\theta t + C'\sin\theta t = M\cos(\theta t+\epsilon) + N\sin(\theta t+\epsilon),$$

whereby equations (b_3) become

$$\left.\begin{aligned} x' &= u\cos(\theta t+\epsilon), \\ y' &= v\sin(\theta t+\epsilon), \\ z &= M\cos(\theta t+\epsilon) + N\sin(\theta t+\epsilon). \end{aligned}\right\} \qquad (b_4)$$

Now, it is possible to identify this with the pendulous elliptic motion

$$\left.\begin{aligned} x'' &= a\cos(\theta t+\epsilon+\alpha), \\ y'' &= b\sin(\theta t+\epsilon+\alpha), \end{aligned}\right\} \qquad (c_1)$$

having the same frequency, and lying in a position which can be determined. For—

Let OX be the intersection of the plane $x'y'$ (which is identical with xy), with the plane $x''y''$; and let β be the angle $x''OX$ and γ the angle $x'OX$. Then equations (b_4) are equivalent to

$$\left.\begin{aligned} X_1 &= u\cos(\theta t+\epsilon)\cos\gamma - v\sin(\theta t+\epsilon)\sin\gamma, \\ Y_1 &= u\cos(\theta t+\epsilon)\sin\gamma + v\sin(\theta t+\epsilon)\cos\gamma, \\ Z_1 &= M\cos(\theta t+\epsilon) + N\sin(\theta t+\epsilon), \end{aligned}\right\} \qquad (b_5)$$

the two former being in the plane xy, and X_1 being along OX, the line of intersection.

Again, equations (c_1) are equivalent to

$$\left.\begin{aligned} X'' &= a\cos(\theta t+\epsilon+\alpha)\cos\beta - b\sin(\theta t+\epsilon+\alpha)\sin\beta, \\ Y'' &= a\cos(\theta t+\epsilon+\alpha)\sin\beta + b\sin(\theta t+\epsilon+\alpha)\cos\beta, \end{aligned}\right\} \qquad (c_2)$$

in the plane $x''y''$, X'' being along OX, the line of intersection. This, if ω be the angle at which the planes xy and $x''y''$ are inclined to one another, is equivalent to—

$X_2 = X''$ along the line of intersection,

$Y_2 = Y''\cos\omega$, in the plane xy, and perpendicular to the line of intersection.

$Z_2 = Y''\sin\omega$, along Oz.

Thus the motion (c_2) is equivalent to

$$\left.\begin{aligned} X_2 &= a\cos(\theta t+\epsilon+\alpha)\cos\beta - b\sin(\theta t+\epsilon+\alpha)\sin\beta, \\ Y_2 &= [a\cos(\theta t+\epsilon+\alpha)\sin\beta + b\sin(\theta t+\epsilon+\alpha)\cos\beta]\,.\cos\omega, \\ Z_2 &= [a\cos(\theta t+\epsilon+\alpha)\sin\beta + b\sin(\theta t+\epsilon+\alpha)\cos\beta]\,.\sin\omega, \end{aligned}\right\} \qquad (c_3)$$

which we shall identify with the motion (b_5) if we can determine a, b, α, β, γ, and ω, so as to make the coefficients of $\cos(\theta t+\epsilon)$ and $\sin(\theta t+\epsilon)$ identical in equations (b_5) and (c_3).

Now, the equations (c_3) are identical with

$$\left.\begin{aligned} X_2 &= \cos(\theta t+\epsilon).k - \sin(\theta t+\epsilon).p, \\ Y_2 &= [\cos(\theta t+\epsilon).q - \sin(\theta t+\epsilon).r].\cos\omega, \\ Z_2 &= [\cos(\theta t+\epsilon).q - \sin(\theta t+\epsilon).r].\sin\omega, \end{aligned}\right\} \qquad (c_4)$$

in which

$$\left.\begin{aligned} k &= a\cos\alpha\cos\beta - b\sin\alpha\sin\beta, \\ p &= a\sin\alpha\cos\beta + b\cos\alpha\sin\beta, \\ q &= a\cos\alpha\sin\beta + b\sin\alpha\cos\beta, \\ r &= a\sin\alpha\sin\beta - b\cos\alpha\cos\beta. \end{aligned}\right\} \qquad (d)$$

Identifying the coefficients in (b_5) and (c_4) we find that the equations to be satisfied are—

$$k = u\cos\gamma, \qquad (e_1)$$

$$p = v\sin\gamma, \qquad (e_2)$$

$$q\cos\omega = u\sin\gamma, \qquad (e_3)$$

$$r\cos\omega = -v\cos\gamma, \qquad (e_4)$$

$$q\sin\omega = M, \qquad (e_5)$$

$$r\sin\omega = -N. \qquad (e_6)$$

From (e_3) and (e_5), we find that

$$\tan\omega = \frac{M}{u\sin\gamma}. \qquad (f_1)$$

Similarly, from (e_4) and (e_6) we find that

$$\tan\omega = \frac{N}{v\cos\gamma}. \qquad (f_2)$$

Equating these, we find that

$$\tan\gamma = \frac{vM}{uN},$$

which determines γ. Having found γ, equations (e_1) and (e_2) determine k and p, and equation (f_1) determines ω; and having found γ and ω, either equations (e_4)

and (e_5) or equations (e_5) and (e_6) will determine q and r, and the determinations in whichever way made are identical. Hence k, p, q, and r become known, and equations (d) enable us from them to determine a, b, α and β.

Hence, the form (a, b), the phase $(\alpha + \epsilon)$, and the position (β, γ, ω), of the elliptic motion, can be determined in terms of u, v, M, N, and ϵ, of equations (b_4); and thus, through them, the elliptic motion is completely determined in terms of the coefficients A, A', B, B', C, C' and θ, of one of the vertical columns of equations (a_2). We accordingly arrive at the conclusion that—

> Theorem B.—Any motion of a point in space may be regarded as the coexistence and superposition of one definite set of partials which are the pendulous elliptic motions determined as above from the several vertical columns of equations (a_2).

These partials will, in general, lie in different planes, and be in different phases. The periodic time of each will be the periodic time of that vertical column of equations (a_2) from which it is derived. Seven constants are associated with each partial—of these, a, b, and θ give the ellipse and the swiftness of motion in it, γ and ω give the position of its plane, β gives its position in that plane, and finally $(\alpha + \epsilon)$ gives the position in the ellipse at which P was at the instant $t = 0$.

Before proceeding further it may be well to refer again to an objection that is likely to be felt. It may at first sight seem very improbable that within a molecule there can be parts of it moving so freely as to describe definite orbits that suffer steady perturbation. But we must remember, as was pointed out on p. 564, that in dealing with the internal motions of molecules we have reached a stage where there is no longer *any* degradation of motions such as that effected by friction or viscosity—in fact where the motions, whatever they are that occur in a molecule during its flights, are performed without loss of energy other than that communicated to the æther—with *no loss whatever arising from the dynamical relations of the parts of the molecule to one another.*

The only alternative hypothesis is that the molecules are rigid. Here we might have a rotation, and if the three principal moments of gyration were unequal we should have the instantaneous axis describing an elliptic cone, and so supplying the condition for double lines. But, nevertheless, the hypothesis is inadmissible, as it would necessitate a constancy in the rotation which is inconsistent with the varying brightness of the spectrum at different temperatures, and which indeed independently of this could not survive the collisions that are going on, as is evident from dynamical considerations. We may therefore adhere with confidence to the hypothesis made in this Memoir, that there are relative motions going on within the molecules which are unimpeded except by the æther.

CHAPTER V.

ILLUSTRATIONS.

When a chord is played by an orchestra, a very complicated undulation spreads around it through the air. This involved motion admits of two successive resolutions into simpler elements, first by regarding it as the coexistence and superposition of undulations emanating from the several instruments each of which by itself would produce the effect on the ear of a musical note; and next by the further resolution of the note emitted by each separate instrument into its pendulous elements whose coexistence is what gives to the tone of that instrument its special quality. So long as the undulation advances through the air, these elements are not separated from one another; but their presence is indicated analytically in the fullest detail by Fourier's theorem, and the ear of a highly trained musician is a means by which they may in practice be partially distinguished. Such a person can completely effect the first resolution, *i.e.* can distinguish each separate note, and can imperfectly effect the second resolution, *i.e.* he can distinguish the qualities or clangs of these separate notes; but his ear is powerless to complete the resolution by distinguishing the individual partials or pendulous elements, whose presence is what determines the distinctive sound of each instrument. Now that which the ear does imperfectly in the case of sound the spectroscope does fully in the case of light.

In this comparison between light and sound, each molecule of the gas corresponds to the entire orchestra; and the orbits described within it by its several electrons are what correspond to the vibrations of the sounding-boards, columns of air, &c., of the instruments, these being the parts of the orchestra which act directly on the surrounding medium. The undulation in the luminiferous æther which emanates from a molecule of the gas corresponds to the waves that fill the atmosphere when a chord is being played by the instruments of the orchestra. That we can resolve this into the notes emitted by the individual instruments corresponds to our being able in some cases to divide the lines of the spectrum of a gas into groups, each of which may be attributed to the motion of one of its electrons. The patterns which we may observe in these groups of lines correspond to the clangs or qualities of the notes of the orchestra; and, finally, the individual lines themselves supply us directly with the intensities and periodic times of the individual partials which are the ultimate elements into which Fourier's theorem resolves every undulation of the æther, however complex.

The "partials" or ultimate elements into which a sound-wave in air can be resolved take the very simple form—

$$x = a \cos \theta t.$$

They are pendulous vibrations in a straight line, and we may regard each of them as fully characterized if we can ascertain the values of its a and θ. These are furnished by the intensity and pitch of the corresponding simple sound, which can be determined experimentally by the use of resonators.

This simplest form is also the form of the ultimate elements into which the motions going on in the instruments of the orchestra are to be revolved. They are all partials of the form $x = a \cos \theta t$, fully characterized when we can determine a and θ.

If, however, we want to make out what is the actual motion that is going on, it is not sufficient to characterize its individual partials correctly, it is also necessary to be able to combine them: and to do this we must know the phases in which they all have been at some one instant of time. Now it is still a moot point whether we can elicit any information about the phases from an analysis of the resultant sound: we certainly cannot elicit enough of information in this way. To acquire it we must have recourse to a study of the instruments from which the sound has come, and, unfortunately, in the case of light we are in the predicament of not being able to do what corresponds to this.

Neither are the partials of the æthereal undulation so simple as in the case of sound. Each æthereal partial is a pendulous elliptic revolution in the plane of the wave, of the form

$$x = a \cos \theta t, \qquad y = b \sin \theta t,$$

or rather it is some change of varying electro-magnetic stresses that follows this law. We may, however, for clearness and convenience, continue to speak of it as a *motion* in the plane of the wave, it being understood that what is meant is some change in the æther which follows the same law as the motion. Now to characterize the above partial of such a motion, three quantities are required, a, b, and θ; and what we can observe by separately examining its spectral line is not enough to determine three quantities. The position of the line on the map of oscillation-frequencies tells us the value of θ, its intensity determines $a^2 + b^2$, and this is all that is given us by the examination of a single line. We have enough, however, if we independently know of some other equation between a and b. Thus from Chap. II. we know that $b = + a$ for one of the two constituents of a double line, and that $b = - a$ for the other. In the case of double lines, therefore, the two corresponding partials of the motion in the æther *are completely determined.* Again, if satellites arise in any of the ways pointed out in Chap. II., when not due to circular, they are due to *rectilinear* vibrations. Here again, since $b = o$, the partial

may be completely determined by observation of the line. Now it is probable that all the lines of the spectra of H, Li, Na, K, Rb, and Cs fall into one or other of these categories, and if this is so, *all the partials of the æthereal undulation causing these spectra can be determined by observations with the spectroscope.*

We have next to consider the motions going on in one of the molecules of the gas. These correspond to the motions going on in an orchestra; and of them the only ones to which we have a direct clue are the motions of the electrons themselves, since we can only work back from the effect on the æther and these are the only motions in the molecules that act directly on the æther. They correspond to the motions of the sounding-boards of the stringed instruments and the columns of air in the wind instruments of the orchestra, as these are what act directly on the surrounding atmosphere.

Here, again (see last chapter), the motion of the electron may be resolved into elliptic partials of the form,

$$x = a \cos \theta t, \qquad y = b \sin \theta t;$$

but as the electron is not necessarily confined to one plane, we must remember that its path may be a curve of double curvature, in which case the elliptic partials will lie in different planes, see p. 591.

CHAPTER VI.

APPLICATIONS.

We may, however, best form a judgment as to how far observations with the spectroscope will carry us by studying some one spectrum. The spectrum of any of the above-mentioned monads would do, but amongst them that of sodium seems the best adapted for our purpose.

Professor Rydberg has collected and analyzed the principal observations on this spectrum, and I follow the selection from amongst them which he made, adding to them the determinations since made by Professors Kayser and Runge. Thirty-five lines, thirteen double lines and nine others, had been observed.* Professor Rydberg conjectures that they are all, except one satellite, double. In this connexion it should be noted that, in accordance with the analysis given above on page 572, even where there is the apsidal motion which produces double lines, one of a pair may be of cypher intensity, and, accordingly, the line as it appears in

* Two others more refrangible, and belonging to series P, have since been announced by Professors Kayser and Runge.

the spectrum may be single. This will happen whenever the corresponding pendulous component of the dominant motion of the electron is circular.

Of the thirty-five known lines, Professor Rydberg arranges thirty-two in the three following series,* and the three remaining lines he supposes to be satellites of the third and fourth terms of series *D*. We must, however, here be on our guard against lines that are intruders, and owe their presence to impurities in the sodium. We should also bear in mind that they or some of them may be sodium lines which are members of a series, if such exists, the rest of which lies beyond the part of the spectrum that has been explored.

Using the language of acoustics, we may regard the whole spectrum as an optic chord which is being played by the molecules of sodium. Each of Rydberg's series will then be one of the notes of this chord, and the individual lines will be the partials of these notes. The three optic notes are—

Series *P* (the principal series) of lines that form a definite pattern, and in each pair of which the *more* refrangible line is the stronger.

SERIES P.

Term of Series according to Rydberg.	Recorded character of lines.	Kayser and Runge's Measures (on Rowland's Scale).		$\Delta\kappa = \mu . \Delta N$	Earlier determinations of λ (on Ångström's Scale).
		$\lambda = T/\mu$	$\kappa = \mu . N$		
First, ..	Easily reversed, ...	5896·16 5890·19	169·602 169·774	·172	5895·13 5889·12 Ångström.
Second, ..	Easily reversed, ...	3303·07 3302·47	302·749 302·804	·085	3301· 2 3300· 8 Cornu.
Third, ..	Easily reversed, ...	2852·91	350·519	—	2853· 3 Liveing and Dewar.
Fourth, ..	Easily reversed, ...	2680·46	373·070	—	2679· 0 Liveing and Dewar.
Fifth, ..	Easily reversed, ...	2593·98	385·508	—	2593· 3 Liveing and Dewar.
Sixth, ..	Easily reversed, ...	2543·85	393·105	—	Kayser and Runge.
Seventh, ..	Easily reversed, ...	2512·23	398·053	—	Kayser and Runge.

* Professors Kayser and Runge, using a different formula from Professor Rydberg's, distribute them into the same three series.

Series D of lines that are *diffuse*, that form a definite pattern when plotted down on a map, and in each pair of which the *less* refrangible line is the stronger.

SERIES D.

Term of Series according to Rydberg.	Recorded character of lines.	Kayser and Runge's Measures (on Rowland's Scale). $\lambda = T/\mu$	$\kappa = \mu . N$	$\Delta\kappa = \mu . \Delta N$	Earlier determinations of λ (on Ångström's Scale).
Second, ..	—	(8200·3) (8188·3)	121·947 122·126	·179	8199 8187 Abney.
Third, ..	Nebulous towards the red, ..	5688·26 5682·90	175·801 175·967	·166	5687·3 5681·5 Thalén.
Satellites(?) ..	Nebulous towards the violet,	5675·92 5670·40	176·183 176·354	·171	5673·6 5668·6 Liveing and Dewar.
Fourth term and Satellite (?)	Nebulous towards the red, ..	4983·53 4979·30	200·661 200·831	·170	4983 4982 4980·5 Liveing and Dewar.
Fifth, ..	Nebulous towards the red, ..	4669. 4 4665· 2	214·160 214·353	·193	4667·5 4663·7 Liveing and Dewar.
Sixth, ..	Very nebulous, ...	4500· 0 4494· 3	222·222 222·504	·282	4496·4 4494·5 Liveing and Dewar.
Seventh, ..	Nebulous, ...	(4393· 7) (4390· 7)	227·599 227·754	·155	4393 4390 Liveing and Dewar.
Eighth, ..	Part of a band, ...	(4325· 7)	231·177	—	4325 Liveing and Dewar.

Series S of lines that are *sharp*, that form a definite pattern, and in each pair of which the *less* refrangible line is the stronger—

SERIES S.

Term of Series according to Rydberg.	Recorded character of lines.	Kayser and Runge's Measures (on Rowland's Scale). $\lambda = T/\mu$	Kayser and Runge's Measures (on Rowland's Scale). $\kappa = \mu . N$	$\Delta\kappa = \mu . \Delta N$	Earlier determinations of λ (on Ångström's Scale).
Second, ..	— ..	(11421·9)	87·550	—	11420 Becquerel.
Third, ..	Slightly nebulous towards the red	6161·15 6154·62	162·307 162·480	·173	6160·2 6154·4 Thalén.
Fourth, ..	Slightly nebulous on both sides,	5153·72 5149·19	194·035 194·205	·170	5155·0 5152·7 Thalén.
Fifth, ..	Slightly nebulous on both sides,	4752·19 4748·36	210·429 210·599	·170	4751·4 4747·5 Liveing and Dewar.
Sixth, ..	Slightly nebulous on both sides,	4546·03 4542·75	219·972 220·131	·159	4543·6 4540·7 Liveing and Dewar.
Seventh, ..	Sharp, ...	(4423·7) (4420·2)	226·055 226·234	·179	4423·0 4419·5 Liveing and Dewar.
Eighth, ..	Part of a band, ...	(4343·7)	230·219	—	4343 Liveing and Dewar.

In these Tables—

λ (the wave-length in air, measured in tenthet-metres) is given by observation.

κ (the "inverse wave-length," the number of waves in the tenth of a millimetre in air) $= 10^6/\lambda$.

T (the periodic time of the oscillation measured in micro-jots) $= \mu\,\lambda$.

μ being the index of refraction of air for that wave-length.

N (the "oscillation-frequency," *i.e.* the number of oscillations in each jot of time) $= \kappa/\mu$.

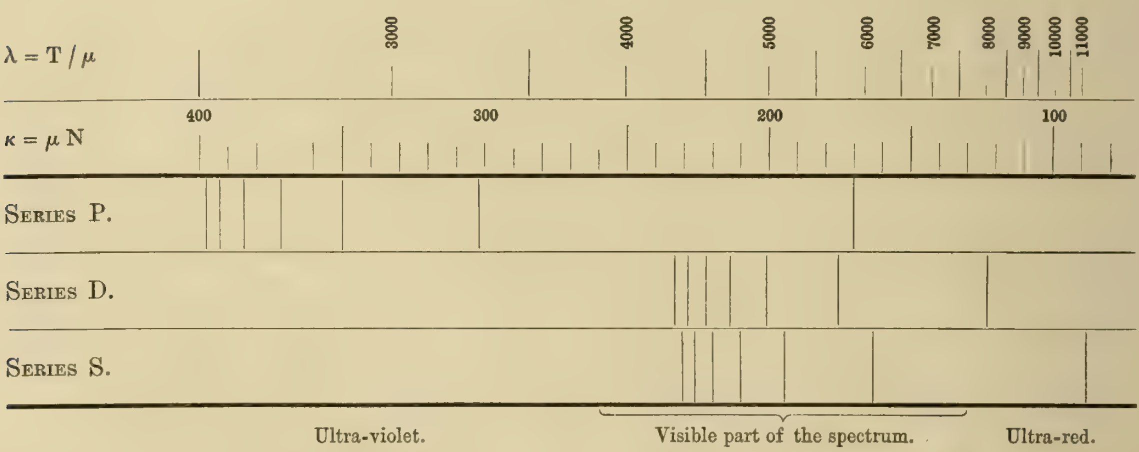
ΔN (the interval between the constituents of a double line on a map of oscillation frequencies) $= \Delta\,\kappa/\mu$.

The numbers in brackets are determinations not made by Kayser and Runge. They are the earlier determinations reduced to Rowland's scale.

An accurate determination of the values of μ throughout the spectrum is *very* much wanted. However, so far as ΔN is concerned, μ differs so little from unity that ΔN need not be distinguished from $\Delta\kappa$, until much more refined observations are made than those hitherto recorded.

These three optic notes *P*, *D*, and *S*, with possibly a fourth one (the existence of which there is some slender ground to suspect), make up the optic chord emitted by the molecules of sodium. Nor is the case of sodium an isolated one: all the other light monad elements, Li, K, Rb, Cs, emit optic chords of essentially the same character, consisting of three notes *P*, *D*, and *S*, closely resembling those of sodium in many important respects.

The optical clang of these notes—the relation in which their partials stand to one another—may be roughly exhibited to the eye by plotting them down on separate maps of oscillation-frequencies, when the pattern which the lines make becomes conspicuous. The scale of the diagram is too small to show that any of the lines are double. In fact, most of them are so (see foregoing Tables).



The spectrum as seen has the much more disorderly appearance which would result from plotting them all down on one map.

Professor Rydberg is of opinion that the value of $\Delta\kappa$ (the interval between the constituents of each pair) is the same in all the pairs of sodium, and that the recorded discrepancies are due to the roughness of the observations. This is a matter that careful observations will decide. Meanwhile we are concerned with studying the *inferences* that can be drawn; and in order to do this it will be convenient to take series *S* first.

Series S.

S (*a*). If, as appears to be the case, Series *S* consists of double lines none of which has a satellite midway between its components, it follows from our investigation that—

> The path of the electron, from which this series arises, *is a plane curve.*

S (*b*). If further, as Professor Rydberg supposes, the $\Delta\kappa$'s (or rather the ΔN's, which are practically undistinguishable from the $\Delta\kappa$'s) are identical in the several double lines of the series, it will follow that—

> The dominant orbit of the electron (as started by the last encounter with another molecule) is affected during the subsequent flight of the molecule by an apsidal perturbation, which carries the orbit *as a whole* round in its own plane, without altering its form.

S (*c*). If, moreover, as Professor Rydberg concludes from the observations, the less refrangible line of each of the pairs is the brighter, it will follow that—

> The elliptic partials of which the undisturbed orbit consists are all described *in the same direction*, and that *this direction is the reverse of that in which the apsidal motion takes place.*

S (*d*). No satellites such as those described in Problem III., p. 576 have been recorded in connexion with the lines of this series. If further observation establishes the fact that none such exist, it will follow that—

> The perturbating forces do not occasion any precession.

S (*e*). Professor Rydberg concludes from the observations that $\Delta\kappa$ for this series = ·146. The correction which should be applied to this to allow for the dispersion of the air is inappreciable, so that we may take 0·146 as the value of ΔN, the difference of the oscillation-frequencies of the two rays. Now, by Problem II., n (the frequency of apsidal circuits) = $\frac{1}{2}\Delta N$. It is therefore 0·073 or nearly 1/14. If this determination is correct it follows that—

> One apsidal circuit lasts during 14 jots of time; so that about 30 of these will on the average be described during each flight of the molecule between its encounters.

S (*f*). Meanwhile a vast number of revolutions in the elliptic orbits of the partials will have taken place, ranging from 1226 during each of the 30 apsidal circuits in the case of the least refrangible of the observed double lines of the

series, to 3223 revolutions during each apsidal circuit in the most refrangible of the observed pairs. Exact information on these points will be obtainable if adequate observations can be made.

$S(g)$. The actual form of the elliptic orbit of each of the partials can be ascertained from observations on the brightness of the lines. See below, p. 603.

This is a considerable body of information about the motion in the molecules which causes series S, all of which is within our reach if adequate observations can be made.

Series D.

When we turn to the series of diffuse lines, we find that it resembles series S in most respects, with, however, three notable points of difference :—the lines are brighter in series D than in series S; they are diffuse instead of sharp; and some satellites (or supposed satellites) are present.

That the lines are brighter betokens that the partials of the primary motion of the D electron are motions in larger ellipses than those of the S electron; and how much larger may be ascertained so soon as measures of their relative brightnesses shall have been made. As to satellites, three supposed satellites are recorded, one apparently midway between the lines of that which Professor Rydberg regards as the fourth pair of the series. If, when adequate observations are made, it is found to be really midway between them, it will indicate that the corresponding partial lies in a plane which is inclined to the plane of the apsidal motion at an angle which can be determined so soon as the relative brightnesses of the three lines (the double line and its satellite) shall have been measured. See Corollary,* p. 577.

No similarly placed satellites are recorded of the other terms of series D. If upon an adequate scrutiny it is found that there are none such, it will indicate that all the partials of the primary motion, except one, lie in the plane of the apsidal motion. But as there is one which does not lie in that plane, the primary motion of electron D must be a curve of double curvature.

Professor Rydberg thinks the observations warrant the conclusion that $\Delta\kappa$ is the same in all the pairs of this series, and even that it is the same in all the three series. If it has the same value in all the terms of series D, it will indicate that the primary motion of electron D is in an orbit of double curvature which, without changing its form, shifts round in a definite plane (which is the plane of all but one of its partials) with an apsidal motion of which the frequency is $\Delta\kappa / 2$.

* What it is here convenient to regard as apsidal motion in a plane inclined to the plane of the partial, is identical with that which in the Corollary (p. 577) is perhaps more accurately described as precessional motion unaccompanied by apsidal motion.

Finally the lines are diffuse. If it be further the case that they are similarly diffuse, and that the thicknesses of the lines (when plotted down on a map of oscillation-frequencies) are everywhere the same, we must attribute the diffuseness to a common cause, which may be that the apsidal motion of the dominant orbit of electron *D* is not a shifting of the orbit with uniform angular motion, as it is in the case of electron *S*, but that there is a subsidiary perturbation of this motion which bears to it the same relation that nutation does to precession in the rotation of the earth. The oscillation-frequency of this nutation can be determined by measuring the thickness of the lines. See p. 581. As the lines are found to be more winged on their less refrangible side, the subsidiary perturbation that causes them is more complex than a mere pendulous oscillation; but until all that observation can tell us is known it would be useless to search further for the cause.

I have not taken into account the two lines which are close to the third term of series *D*, and which Professor Rydberg regards as satellites to that term. Professors Kayser and Runge conjecture that they do not belong to any of the series *P*, *D* and *S*, but that they are the only visible term of a fourth series of which the rest lies beyond the parts of the spectrum that have been explored; and they point out in support of their view that the constituents of this pair are winged towards the violet, while all the lines that are known to belong to series *D* are winged towards the red. Their positions forbid our attributing them to the circumstances which may produce quadruple lines sketched out in Problems V. and VI. However, we shall be in a better position to deal with this group of four lines when more is known of their distances and intensities.

Series P.

The remaining lines of sodium that have been observed, including the great yellow double line, form another natural group which Professor Rydberg calls the principal series. All but one of the terms of this series are of high refrangibility. Some of them are known to be double lines; in others only a single line is (as yet) recorded. If they turn out to be single, they probably arise from partials that are circular. The recorded observations upon the spectra of sodium, potassium, and rubidium show that $\Delta\kappa$ is not the same in all the pairs of series *P*, which indicates that the perturbating forces acting on Electron *P* are such as to induce different rates of apsidal shift upon the several partials of its dominant motion. Accordingly, the dominant orbit undergoes a change of form as well as of size and position during the flight of the molecule. The double lines of series *P* are characterized by having their more refrangible constituent the brighter, in which respect they differ from the double lines of series *D* and *S*. It

follows that the apsidal motion in series P is *in the same direction* as the revolutions in the partials, whereas in series D and S it is in the opposite direction. In most other respects the analysis of this series is much the same as that which has been applied to series S; and any further separate treatment of series P as a whole is premature till more accurate observations shall have been made.

But the great yellow sodium line which is the first term of the series, and which corresponds to the Frauenhofer line D in the solar spectrum, has been more carefully observed than any other of the sodium lines, and is on this account the best in which to illustrate the extent of the information which can be elicited from observations on a double line in the spectrum.

For this investigation it is best to use the wavelengths-in-air of Professor Rowland's great map of the Solar Spectrum issued in 1888. Reading from it, the wavelengths-in-air of the two D (sodium) lines are—

$$\lambda_1 = 5896{\cdot}15 \text{ tenthet-metres,}$$

$$\lambda_2 = 5890{\cdot}20 \text{ tenthet-metres.}$$

Taking the reciprocals of these, we find the number of waves in the tenth of a millimetre in air to be

$$\kappa_1 = 169{\cdot}602,$$

$$\kappa_1 = 169{\cdot}773\,;$$

multiplying the former, and dividing the latter, by 1·000295 (Ketteler's value for μ, the index of refraction of air, for this part of the spectrum, *Phil. Mag.*, Nov., 1866, p. 341), we find for the wavelength in vacuo, which is the same as the periodic time expressed in micro-jots—

$$T_1 = \mu\lambda_1 = 5897{\cdot}89 \text{ micro-jots,}$$

$$T_2 = \mu\lambda_2 = 5891{\cdot}95 \text{ micro-jots;}$$

and for the number of waves in the tenth of a mm. in vacuo, which is the same as the frequency of the undulation of the æther in each jot of time—

$$N_1 = \kappa_1/\mu = 169{\cdot}552 \text{ in each jot,}$$

$$N_2 = \kappa_2/\mu = 169{\cdot}723 \text{ in each jot.}$$

Now by Problem II., p. 572, $N_1 = m - n$, $N_2 = m + n$, where m and n are respectively the frequencies of the revolution of the electron in its ellipse, and of a complete circuit of the apsidal motion. Hence—

$$m \text{ (the number of elliptic revolutions in each jot)} = \frac{N_2 + N_1}{2} = 169{\cdot}637,$$

$$n \text{ (the number of apsidal circuits in each jot)} = \frac{N_2 - N_1}{2} = {\cdot}0855.$$

From these values it appears that the partial which causes the great yellow double line of sodium is one in which the electron makes $m/n = 1984$ elliptic revolutions, while the apsidal motion carries the ellipse once round. An apsidal circuit is completed in $1/n = 11{\cdot}7$ jots. And there is time for about $420\,n = 36$ of these complete apsidal circuits to take place during the average flight of a molecule between two consecutive encounters, assuming this journey to occupy about 420 jots.

The more refrangible of the two lines is known to be the brighter; and I hope soon to have the means of making a good determination of the ratio of their brightnesses. Meanwhile the best estimate I can at present make gives this ratio as lying somewhere between 3 : 2 and 4 : 3. Now these numbers are nearly in the ratios of 36 : 25 and 49 : 36. We may assume, therefore, that $(a+b)^2 : (a-b)^2$ lies somewhere between these ratios, and that, therefore, $a : b$ lies somewhere between 11 : 1 and 13 : 1. Accordingly the partial in this case is a long-shaped ellipse, in form somewhere between the two ellipses delineated in the figure. Round

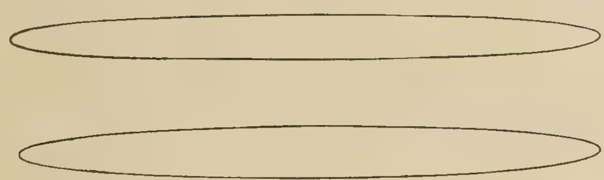


FIG. 13.

this ellipse the electron travels 1984 times while the ellipse shifts gradually once round in the same direction, and something like 36 of these slow apsidal circuits are performed during each rectilinear flight of the molecule. These are the events that occur in the partial which gives rise to the great yellow double line of sodium; and *an equal amount of information may be obtained in the case of every other double line that can be observed with the requisite accuracy.*

It has been mentioned that the three series P, D, and S appear in the spectra of all the light monad elements, except hydrogen, viz. of Li, Na, K, Rb, and Cs; and it may be added that they are found in positions in the spectrum of progressively lower refrangibility in the order in which the elements are named, *i.e.* in the order of their atomic weights. Another remark that should be made is, that when we compare the spectra of these elements with one another the value of $\Delta\kappa$ is found to increase with the atomic weight, showing that the apsidal motion is swifter, and, therefore, that the perturbating force is stronger in the more massive molecules. A series, very much like one of the foregoing, is found in the spectrum of hydrogen, but it is in a situation of too low refrangibility to be any one of these in the case of an element with such low atomic weight.*

* One is almost tempted to conjecture that all the light monads, including hydrogen, have similar spectra, and that there are four series in each, H, P, D, and S, of which H appears in the spectrum of

The spectra of the heavier monads, Cu, Ag, and Au, have not been sufficiently explored to be used here for purposes of illustration. They appear to consist of double lines, one of the constituents of which is often faint, and has been recorded as a satellite, indicating that the elliptic partials in these cases are open ellipses approaching in form to the circle. In the spectra of elements of higher atomicity triple lines present themselves, the discussion of which lies beyond the scope of the present Paper.*

It appears from the investigation developed in this Paper, that when the lines of a spectrum are double, it is possible to extract from the observations a great deal of information as to each of the elliptic motions which, when put together, make up the actual motion of the electron. It remains to consider whether it is possible to combine them, and so to ascertain what the actual motion is.

Where, as in the case of hydrogen, such a law as Balmer's can be empirically obtained, there can be no doubt that all the lines (or pairs of lines) connected by so explicit a law, arise from the successive partials of the actual motion of one electron. Neither can there be a reasonable doubt where, by graphical processes or by using approximate empirical formulæ like that of Professors Kayser and Runge or that of Professor Rydberg, it is found possible to pick out the lines belonging to a natural series, especially when, as generally happens, the lines so indicated are found by observation to have characteristics in common. The whole of such a series we may with confidence refer to the motion of one of the electrons in the molecules of the gas. In both these cases observations with the spectroscope will give much information about the several partials of the motion of the electron.

But all this information falls short of being sufficient to enable us to give

hydrogen, but has not yet been detected in the spectra of the others because of its very low refrangibility in them, and of which *P*, *D*, and *S* lie so far in the ultra-violet in the spectrum of hydrogen that they have not yet been observed.

* In the present Memoir we are dealing only with perturbating forces that are feeble. If the perturbating forces were comparable with the forces which produce the orbit which we select as the dominant orbit, triple lines might arise. For example, a motion represented by

$$x = a \cos(\zeta t + \alpha) \, . \cos(\eta t + \beta) \, . \cos \theta t,$$

in which ζ, η and θ have nearly equal values, would produce a triple line in association with a single line far separated from it.

It thus appears that even a vibration in a straight line may be such as will produce triple lines. And, of course, more complex motions can generate them under fewer restrictions. But in all cases, if (as is always possible) the motion be resolved into motion in a simpler 'dominant' orbit affected by perturbations, the perturbations, or some of them, must be of large amount, *i. e.* must have periodic times which are comparable with that of the motion in the 'dominant' orbit. In fact, slow perturbations give rise to close equidistant lines, so that triple lines, other than those that are equally spaced, can arise only in cases where the orbit corresponding to our dominant orbit is not predominant over some of its perturbations.

a full symbolical representation of the resultant motion. If e_m represents the elliptic partial whose frequency is m, then the resultant motion may be concisely represented by the symbolical equation

$$\text{Resultant motion} = e_{m1} \dotplus e_{m2} \dotplus e_{m3} \dotplus \&c.,$$

where the symbol $\dotplus$ signifies "superposed upon." Now, of these several elliptic components, we can obtain from the observations full details, except unfortunately in at least two particulars. There is nothing in the spectrum which can reveal to us the phases in which either they, or the apsidal motions by which they are affected, are at any one instant of time: and these phases are essential to the completeness of the symbolical equation, which when written out in full would appear as follows:—

The position of the electron at the instant t

is identical with

the position of the point P at that instant in the pendulous elliptic component whose frequency is m_1

superposed upon

its position at that instant in the pendulous elliptic component whose frequency is m_2

superposed upon,

&c., &c., &c.

There are under the most favourable conditions at all events two unknown constants in each term of the above symbolical equation, and under unfavourable conditions the number of unknown constants may be five—constants to the value of which the appearances in the spectrum give us no clue.

Under these circumstances the best course would appear to be to frame hypotheses as to what the motion of the electron is, and to find whether we can think of any motion which would have elliptic partials with the periodicities, forms, relative amplitudes, and directions of motion which the observations indicate, and which would retain their periodic times through a great range of temperature.

One naturally thinks first of the motion of an electron travelling without friction along a prescribed path under the influence of a central attraction varying directly as the distance. The curve to which it is trammelled being represented by

$$r = kF(\theta),$$

the function F may evidently be such as to produce the observed series of lines; and if the dynamical conditions were such that F does not alter during the flight of the molecule, k must diminish when energy is transferred to the surrounding

æther. This represents a state of things under which, though the size of the curve would dwindle during the flight of the molecule, the periodic times would remain unaltered, and the lines in the spectrum unchanged in position. However, though this agrees in many respects with what is observed, the conditions are evidently not so simple, since under these conditions the lines of the spectrum, while fainter at lower temperatures, would retain the same relative intensities at all temperatures, which is not the case.

If the vortex theory of ponderable matter be true, it is in the study of the dynamical, or rather kinematical, relations in, and in the neighbourhood of, vortex rings and tangles, that we must put our hope. The vortex hypothesis, however, would suggest charges of magnetic moment rather than of statical electricity as associated with the atoms of ponderable matter. Perhaps both are present, and that the electrical charges are maintained by motions of the magnetism. Some motion of this kind must apparently be consequent on the velocity of over 30,000 metres per second with which the molecule, in common with the rest of the earth, is travelling through the rectilinear vortices of the æther. We must remember, too, that statical charges of electricity consist of motions or stresses not in the molecules themselves but elsewhere. These considerations naturally suggest others, but we need not follow them up, as it is unnecessary for our present purpose to do so. This is fortunate, since we can as yet only grope in the region which concerns itself with the fundamental facts of nature.

Whatever our ignorance on such subjects may be, one solid advance seems to be harvested by the investigation in the foregoing pages. It has shown how to interpret the spectrum of a gas when, as in the case of the monad elements, it consists of double lines, so as to extract from the observations important particulars about the several pendulous elliptic components of some of the motions going on within the molecules; it indicates the character and the limits of the information about these motions which the spectroscope can supply; and it puts us on the track of further knowledge by guiding the hypotheses that we should frame. It also cannot fail to impress upon us what an amazingly complicated system even one molecule of matter is; what an inconceivable number and variety of events are crowded into every speck of space about us, within even the millionth part of one second of time; and how very little about nature is yet known to man.

In this branch of investigation we are wofully in want of more minutely exact and fuller observations on the spectra of gases than have yet been published. It may be hoped that there will be a great improvement in this respect when the great work is published which has been recently announced by Professor Rowland from the laboratory of the Johns Hopkins University.

But this great work will lose much of its availability for such inquiries as the present, unless it be accompanied by *equally exact* determinations of the refractive indices of air throughout the spectrum. We cannot even verify Balmer's law without these essential co-efficients.

POSTSCRIPT.

A good illustration of the time-relations of the motions that are concerned in the production of spectral lines can be very simply made by screwing a small hook into the middle of the lintel at the top of a doorway, and hanging a heavy bob from it by a piece of silk or pack-thread of such a length that the middle of the bob is 39 inches from the hook—about as long as an ordinary door is wide. The oscillation period of this conical pendulum will be two seconds, the same as that of a pendulum beating seconds.

Place a table in the doorway, and on it some kind of pointer, such as a candle or bottle, supported by a box if necessary to make it reach nearly to the bob.

Now start the bob in a long (approximate) ellipse. We may take this to represent the motion of the electron in a molecule of sodium, as it swiftly revolves in that elliptic partial which produces the great yellow sodium line. The ellipse of our conical pendulum will be seen to have an apsidal motion owing to the resistance of the air. It is in the same direction as the revolution of the bob in the ellipse. This is the right direction to represent the apsidal motion which takes place in the molecule, but it is probably too swift. The apsidal circuit in our apparatus may perhaps be completed in some five or ten minutes, whereas, to correspond with the real event in the gas, it should take $1^h\,6^m\,8^s$ to get through each revolution. Further, the bob parts with its energy to the surrounding medium far too hastily, and will perhaps come to rest in less than an hour. It should be able to persist in describing its orbit for several months, to be like the electron. There is, however, no difficulty in making allowance for these defects. We should, then, suppose the bob to be given a fresh impulse some eight or nine times every fortnight, to represent on the time-scale that we have chosen the recurrence of the encounters between the molecule and its neighbours, which from time to time revive its internal motions. Finally we are to imagine our pendulum kept going in this way without intermission for thirty-two years; by which time the number of the several representative events in the apparatus will have just accumulated up to being the same as the number of the corresponding *actual events* that are going on within each molecule of the vapour of sodium *in every millionth of a second.*

Another observation of general application seems worth making here. Each molecule of gas at atmospheric pressures and temperatures, meets with about 7000 encounters in the millionth of a second, and of course those which fall to the lot of one molecule must happen under a great variety of circumstances. Moreover, *immense* numbers of these molecules are present, something like a thousand millions* in every cubic micron of air; while in the liquid state they are still more numerous, about a thousand times as many of the gaseous molecules being now crowded into each cubic micron. They are besides now jostled almost without intermission, instead of each encountering its neighbours only at intervals, as in a gas. There are therefore abundant chances for *extremely* rare circumstances to occur in their struggles with one another, at what we should deem very short intervals of time and space; and it is probable that many important chemical and physiological effects that appear to us to take place with even explosive promptitude, have in reality to wait long (from the molecular standpoint) for their appropriate opportunity to arise.

* See *Phil. Mag.* for August, 1868, top of page 141. Readers of the Paper here referred to are requested to change the square of 16, at the end of the second paragraph on p. 134, into the square root of 16. The micron in use among microscopists is the thousandth part of a millimetre. About 70 or 80 of the cubic microns would fit into one blood corpuscle.

NOTE ADDED IN PRESS.

Add the following footnote on p. 567:—

See Tables, pp. 595–597, and a Diagram, p. 598, of the three series of double lines in the spectrum of one of the light monad elements. The spectrum selected as an example is that of Sodium, and the spectra of the others, viz. Lithium, Potassium, Ruthenium, and Cæsium, are of the same character.

XII.

A REVISION OF THE BRITISH ACTINIÆ. PART II.: THE ZOANTHEÆ.

By ALFRED C. HADDON, M. A. (Cantab.), M.R.I.A., Professor of Zoology, Royal College of Science, Dublin; and MISS ALICE M. SHACKLETON, B.A. Plates LVIII., LIX., LX.

[Read February 18, 1891.]

CONTENTS.

INTRODUCTION.

The first part of this Revision dealt with a new sub-family of the Sagartidæ, the Chondractininæ, which included the genera Chondractinia, Hormathia, Chitonactis, Actinauge, and Paraphellia. A few notes were made on the genus Sagartia; and details are given of British representatives of *Gephyra dohrnii.* The British members of the families Edwardsidæ and Halcampidæ were described; and the nature of *Gonactinia prolifera* was discussed. An account was also given of the arrangement of the mesenteries in the Zoantheæ. The Paper concluded with a summary of the development of the mesenteries of Actinia; and certain general considerations were advanced on the phylogenetic value of the mesenteries. Unavoidable circumstances caused this first part of the Revision to be heterogeneous in character, and unsatisfactory in many details.

The present instalment of the Revision is confined to a very distinct group of the Actiniæ. Although there has been considerable confusion within the group, the

Zoantheæ themselves have, since the time of de Blainville, been recognized as a well-marked division of the Actiniæ.

With the exception of the genus Sphenopus, and certain free varieties of the genus Epizoanthus, all the members of this group are permanently fixed, and with very few exceptions form colonies, the individuals of which are united by the adhering base or cœnenchyme. The cœnenchyme extends laterally, and from it new polyps arise, which remain permanently connected with the colony.

The cœnenchyme may be band-like or form broad encrusting sheets; usually it is thin, but in the genus Palythoa it is so thick that the polyps are more or less immersed within it. The polyps may be placed at considerable intervals from each other, or they may be crowded together, the latter condition being usually due to gemmation from the base of the polyps rather than from the cœnenchyme.

It is characteristic of the group for the body-wall of the polyp and cœnenchyme to be incrusted with foreign particles—grains of sand, spicules, foraminifera, and such like. Some genera, such as Palythoa and Sphenopus, are always densely incrusted; the incrustations in Parazoanthus vary according to the species from a considerable amount to very few; finally, the genera Zoanthus and Mammillifera are unincrusted.

The Zoantheæ have the same body-regions as other Actiniæ, with the exception of the basal disc, which must necessarily be absent in the colonial forms, and of a physa in the free forms. In all the column is divisible into scapus and capitulum; the former is usually rigid. In nearly all preserved specimens the capitulum is retracted, and this appears to be generally the case when living, for these forms do not fully expand so frequently as most other sea-anemones. The capitulum is usually thrown into triangular ridges.

The tentacles are bicyclic, and may be very short or moderately long. When fully expanded, the oral disc may be flat or projecting. The mouth is always linear. Only one œsophageal groove is present.

The colours are usually various shades of yellow, buff, and brown, due to the sand incrustations; some have varied colours—pink, green, violet, and so forth—but it is very rare for the colours to be so vivid as is customary among other Actiniæ.

Reproduction takes place by means of ova, by basal and cœnenchymatous gemmation, and by fission.

The foregoing are all the characters which are available for the field naturalist, and, until quite recently, were the only ones on which the definition of species and their systematic arrangement were based. These purely external characters are more than usually unsatisfactory for diagnostic purposes; hence

the not unnatural confusion into which the group has fallen, and from which it has, to a certain extent, been extricated through the labours of Erdmann and M'Murrich. In no group is it more necessary to combine anatomical and microscopical examination with the methods of the older zoologists—for the species of Zoantheæ can only be established after sections have been cut and studied. The identification of new material with recognized species requires the utmost circumspection.

It is impossible to determine the genus to which many previously described species belong until the types have been re-discovered, and then submitted to an anatomical investigation. A complete monograph of the group is at present an impossibility. We have, however, ventured as far as we safely could in this direction.

We have investigated the anatomy of eleven species belonging to five genera of Zoantheæ from Torres Straits, besides several other forms, at the same time that we were occupied upon the British representatives. Our Paper on the Torres Straits specimens is published simultaneously with this one, and in the same Journal; and we would ask those who are interested in this group to study both Papers together, for the two are, to a certain extent, complementary to each other.

Methods.—All the specimens examined by us were preserved in alcohol, and when a sufficient quantity of strong alcohol is used this answers perfectly well. We stained the objects whole in borax carmine, imbedded them in paraffin, and cut them with a "rocking" microtome. In a few cases we stained the sections after they were fixed on the slides.

The unincrusted genera are very easy to cut, and so are some of the incrusted forms, especially some of the species of Parazoanthus. Those wishing to study the anatomy of the group cannot do better than commence with *P. axinellæ*, which is very easily cut by the ordinary paraffin method. It was perfectly unnecessary for von Koch to employ his "Schliff-methode" (Morph. Jahrb. vi., 1880, p. 359) when investigating this species. We mention this solely to prevent others from taking superfluous trouble. The different species of the genus Epizoanthus are, as a rule, difficult to sectionize, on account of the incrustations. *E. paguriphilus* is, however, practically free from them; owing to the great thickness of the mesoglœa in this species, celloidin is a better imbedding material than paraffin, as heat has to be employed in the latter method. As a rule, the incrustations in Zoantheæ from coral seas are calcareous, and admit of being readily dissolved away. We use nitric acid for this purpose.

The use which we have made of the Papers of Erdmann and M'Murrich will emphasize the indebtedness of students of the Zoantheæ to those investigators. References to other workers will be duly acknowledged where we

utilize their results. The laborious monograph of Andres has been in constant requisition.

It is now our pleasing duty to acknowledge the assistance of many friends. The Rev. Canon. A. M. Norman and Professor W. C. M'Intosh have generously placed the whole of their collections at our service; and it is due to the considerable number of foreign (Mediterranean and North Atlantic) specimens belonging to the former that we have been enabled to determine several non-British species. The Director of the Marine Biological Laboratory at Plymouth, and Mr. G. Y. Dixon have also supplied us with specimens, as have also our foreign colleagues, Drs. D. C. Danielssen and J. Playfair McMurrich. Finally, we have to thank Dr. E. Perceval Wright for the loan of books and for ready assistance in the solution of taxonomic and synonymic difficulties.

GENERAL ACCOUNT OF THE ANATOMY OF THE ZOANTHEÆ.

The main external characters of the Zoantheæ have already been given in the Introduction; and before giving a detailed account of the anatomy of the group it will be necessary to say a few words as to the anatomy of these Actiniæ.

As in other Actinozoa, the body-wall is composed of three layers: the ectoderm, the mesoglœa, and the endoderm. There is now no need to adduce arguments in favour of the employment of the second of these terms.

The mouth leads into a rather short œsophagus or stomatodæum, the walls of which are often thrown into folds; at one end a distinct and sometimes a very deep groove is present, for which one of us has suggested the name of "sulcus," or sulcar groove. Projecting into the cavity, or cœlenteron of the polyp, from its body-wall, are a number of soft plates which are known as mesenteries; sometimes these are called "sarcosepta," and occasionally they are erroneously spoken of as "septa." The employment of the latter term cannot be too strongly deprecated as leading to confusion with the septa, or calcareous radial partitions of the Madreporaria.

The mesenteries of the Zoantheæ fall under two categories—

(1) The large mesenteries which extend from the body-wall to the stomatodæum, and which alone bear mesenterial filaments and gonads. These are the "perfect mesenteries" or "macrosepta" of authors.

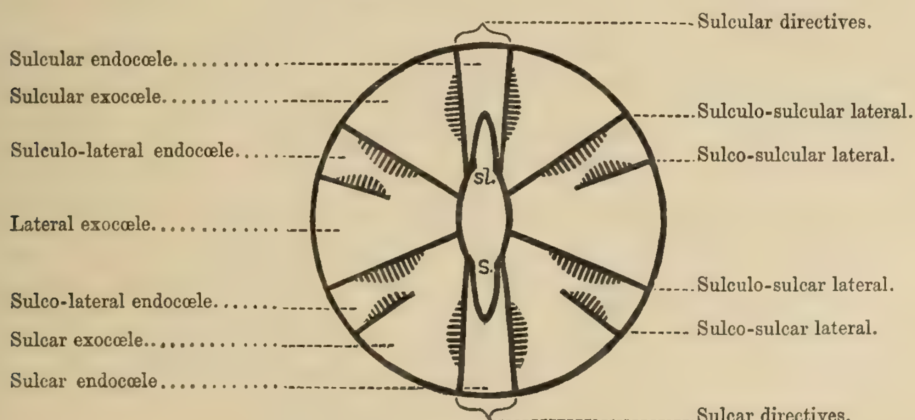
(2) The small mesenteries which extend only slightly from the body-wall into the cœlenteron, and which are sterile, and do not bear mesenterial filaments. These are the "imperfect mesenteries" or "microsepta."

As in most Actiniæ a pair of mesenteries occurs at each end of the œsophagus; these are usually spoken of as the "directives," or "directive mesenteries."

The mesenteries which yield such a valuable aid to classification in the Actiniæ generally are arranged in this group in a very uniform manner.

In the first part of this revision (**1889**, p. 343), a short account is given of the history of the elucidation of the arrangement of the mesenteries in the Zoantheæ. Since this was written the second part of Hertwig's "Challenger" Report has been published, without, however, adding anything to Erdmann's account. M^cMurrich has also written two valuable Papers (**1889** and **1889** A), but no new type of mesenteric arrangement has been described beyond those first pointed out by Hertwig (**1882**), and properly described by Erdmann.

It is necessary to have a recognized system of terminology in order to describe the arrangement of the mesenteries in the Actiniæ; and it is advisable to have such a terminology as is applicable to the whole of the Actinozoa. One of us has already (**1889**) proposed the adoption of certain terms, and the abolition of others which have not a precise meaning—as, for example, such words as "dorsal" and "ventral," these latter were replaced by "sulcular" and "sulcar," respectively. When only one axial œsophageal groove is present, it is usually (? always) the sulcar. In the same Paper attention was called to the value of the order of the appearance of the mesenteries in young Actiniæ, as suggesting the affinities of different groups of sea-anemones. The following diagram illustrates the proposed method of naming the mesenteries and chambers at a stage when twelve mesenteries have made their appearance:—



Examples.—Edwardsia has a pair of sulcular and a pair of sulcar directives; a sulculo-sulcular lateral mesentery, and a sulculo-sulcar lateral mesentery on each side, all of which are perfect.

The larval form of Zoanthus has a pair of sulcular imperfect directives and a pair of sulcar perfect directives; a sulculo-sulcular lateral perfect mesentery, a sulco-sulcular lateral imperfect mesentery, a sulculo-sulcar lateral perfect mesentery, and a sulco-sulcar lateral imperfect mesentery on each side.

The larval form of Epizoanthus agrees with Zoanthus, except that the sulco-sulcar lateral mesenteries are perfect.

In the Zoantheæ new mesenteries appear in the sulcar exocœles in such a way that the mesenteries nearest the sulcus are the youngest, and those furthest from it the eldest.

In the Sagartidæ the new mesenteries appear in pairs in all the exocœles.

The mesenterial filaments, the gonads, the mesenteric canals, and the cœnenchyme will be dealt with later on. We will now proceed to describe the structure of the Zoantheæ in greater detail in the following order :—

Body-wall—ectoderm, incrustations; mesoglœa, cell-enclosures, endodermal bays, ectodermal bays; endoderm, diffuse endodermal muscle, sphincter muscle; capitulum.

Tentacles and Disc.

Œsophagus.

Mesenteries.—Imperfect mesenteries, perfect mesenteries, reflected ectoderm and mesenterial filaments, mesoglœa, canals, endoderm, muscles, gonads.

Cœnenchyme.

Development.

Parasites.

Body-wall.—Ectoderm.—The ectoderm is very liable to be rubbed off in the incrusted genera; where present it generally appears as a continuous layer of narrow columnar cells. In the unincrusted genera, in *Gemmaria macmurrichi* and in *Epizoanthus paguriphilus*, the ectoderm is traversed by strands of mesoglœa, which unite to form a layer peripheral to the ectoderm, and which, in some species break up the ectoderm into more or less cubical blocks (Pl. LIX., fig. 6).

External to the ectoderm there is always a cuticular layer which may be very thin, and stains of a darker colour (*Parazoanthus dixoni*, Pl. LIX., fig. 9), or it may be thick, in which case it rarely stains, and is often impregnated with dirt (*Epizoanthus wrightii*, Pl. LIX., fig. 3).

As the cuticle is an ectodermal secretion in forms with a continuous ectoderm, and, as the peripheral layer of mesoglœa must also be of ectodermal origin, and is, as a matter of fact, often indistinguishable from the cuticle, we do not consider it of any importance to discriminate between them in the forms with discontinuous ectoderm.

The above-mentioned layer of mesoglœa, peripheral to the ectoderm, is that which is called the subcuticle by Andres (**1877**, p. 222).

The ectoderm usually contains nematocysts, which McMurrich and others have failed to observe. As a rule these do not stain readily. In some species they are clear; in others—*e. g. E. norvegicus* (Pl. LIX., fig. 5), where they are, by-the-by,

unusually numerous—they contain pigment granules. In *E. paguriphilus* they are very dark; often they have a yellowish colour, and are somewhat opaque.

Zooxanthellæ are present in the ectoderm of the three species of Isaurus which have been microscopically examined, and in many other species of the Brachycneminæ, but apparently not in all. We have not found them in any of the Macrocneminæ.

Incrustations.—The incrustations which form such a characteristic feature of this group of Actiniæ are absent in the genera Zoanthus and Isaurus, though very rarely a stray spicule, or grain of sand, may be entangled in the cuticlar layer of these genera.

With regard to the other genera, according to our experience, it appears that certain species have a proclivity for a particular kind of incrustation. The character of the incrustation must be conditioned by the precise habitat, *i.e.* whether sand-grains are calcareous or siliceous, or, again, whether the bottom is sandy or stony; if sponges are abundant on a rocky bottom (as, for example, in Albany Pass, Torres Straits), the forms will probably largely make use of sponge-spicules, as in *Parazoantha douglasi.* The best example we have of apparent selection is in the case of *Epizoanthus incrustatus;* of this species we have cut specimens from Norway, Shetland, West of Ireland, and N. E. America (*E. americanus*, Verrill), and in all cases we find the incrustations to be composed almost entirely of grains of sand. In the single specimen we have been able to examine, of *E. macintoshi*, from Shetland, the incrustations are almost entirely Foraminifera. In Norman's type specimens of *Parazoantha anguicoma*, from Shetland, the incrustations include grains of sand, Foraminifera, and sponge spicules; this holds good for the same species from the West of Ireland, as well as for the other species (*P. dixoni*) from the same district.

The amount of incrustation also varies—for example, the species of Epizoanthus are usually thickly incrusted, but in *Epizoanthus paguriphilus* the incrustations are very few in number. In *Parazoanthus dichroicus* there are very numerous incrustations, but in *P. axinellæ* they are sparse, and in *P. dixoni* there are still fewer.

Mesoglœa.—The mesoglœal ground substance is always homogeneous; it is penetrated by numerous minute cells, which are sometimes star-shaped, but more frequently produced at each end into a long fibril which extends in a radial direction. Some of these fibrils are undoubtedly connected with the ectoderm, and others with the endoderm (Pl. LXIV., fig. 1)*; it is impossible to determine whether some may not stretch right across the mesoglœa. We have not been able to satisfy ourselves of their presence in every case (ex. *E. wrightii*).

* Plates LXI. to LXIV. will be found in the Memoir of these Transactions immediately succeeding this one, viz. that on the Zoantheæ of Torres Straits. They are frequently referred to in the present account of the anatomy of the group.

Cell enclosures.—Large ectodermal canals, penetrating the mesoglœa, are very characteristic of the genus Zoanthus; they also occur in Parazoanthus. In *Z. coppingeri* there are numerous large anastomosing canals which arise from the ectoderm (Pl. lxii., fig. 1), and have a general radial direction; many of the canals pass into the mesenteries.

In Isaurus the canals are relatively much smaller than in Zoanthus, and are more broken up than in *Z. coppingeri*, and undoubtedly have an endodermal as well as an ectodermal origin (Pl. lxiii., figs. 5 and 6).

The chief feature of the canal system in Parazoanthus is the presence of an encircling sinus, which lies just beneath the endoderm, and extends throughout the whole body-wall. This sinus is not everywhere continuous, but is frequently crossed by bars of mesoglœa (Pl. lix., fig. 8). It is connected with the ectoderm by radial, occasionally branched canals. In *P. anguicoma* and *P. dixoni*, and in some other species, very fine canals connect the sinus with the endoderm (Pl. lix., fig. 9). Although the encircling sinus may have connexions with the endoderm, these are very delicate, and the sinus itself is undoubtedly of ectodermal origin. The encircling sinus is the same as the "ring-canal" described by Erdmann in his "sp. 8 Palythoa sp." (1885, p. 469). [This is the *Palythoa anguicoma* of Hertwig, which we believe to be another species, for which we would suggest the name *Parazoanthus hertwigi.*] Nematocysts are present in the canals of many of the species of Zoanthus and Parazoanthus; possibly they are of universal occurrence in the canals.

In *Gemmaria macmurrichi* a somewhat similar encircling sinus is present, but it is very largely broken up by the mesoglœa into a number of vertical canals which appear in transverse section as a series of lacunæ, each one lying immediately below the union of a mesentery with the body-wall (Pl. lxiii., fig. 7). These vertical canals are often connected by finer ones.

Lacunæ are found in all the genera of the Zoantheæ except Epizoanthus and Sphenopus. In Zoanthus it appears that the canals are more or less broken up to form the lacunæ, least so in *Z. coppingeri* and *Z. danæ* (as identified by Hertwig), and most so in *Z. jukesii* (Pl. lxii., fig. 2), in which species continuous canals are rare; the same also obtains in *Isaurus asymmetricus.* In Palythoa there are no continuous canals; but lacunæ are present, as these are so similar to those which we know to be of ectodermal origin in other species; and as nematocysts are present, we believe that these lacunæ are of ectodermal origin (Pl. lxiii., figs. 8 and 9).

Small groups of cells, irregularly scattered in the mesoglœa, are especially characteristic of the genus Epizoanthus; they may be very numerous, as in *E. paguriphilus* (Pl. lix., fig. 6), and in some of the species described by Erdmann, but in other species, *E. incrustatus*, *E. couchii*, and *E. wrightii*, they are very rare. They

are abundant in the *Parazoanthus dichroicus*, and are also common in *P. anguicoma*, and *P. douglasi.* They occur also in *Gemmaria macmurrichi*, *Palythoa howesii*, and *P. kochii.*

We have no proof that these small and isolated groups of cells, which have been aptly termed "cell-islets" ("Zellinseln") by Erdmann, are connected in any way with the canals or the lacunæ, and, like that investigator, we do not know their origin. We regard these islets as simply groups of ordinary mesogløeal cells.

Endodermal and ectodermal bays.—We may here refer to the endodermal bays described for *Isaurus* ["*Mammillifera*"] *tuberculatus* by McMurrich (**1889**, p. 118); he says: "In some of my sections deep bays can be seen running from the endoderm into the mesoglœa, and from their ends and sides numerous canaliculi can be seen branching out. These bays can be found in various states of enclosure by the mesoglœa, the cells which they contain being in some cases continuous with the general endoderm, in other cases almost separated from it, and finally quite so. So, too, with the ectoderm." We have found similar deep endodermal bays in *Isaurus asymmetricus* (Pl. LXIV., fig. 9), but in no case were the bays quite separate from the general endoderm. In our species the ectodermal bays (Pl. LXII., fig. 4) differ considerably from those of McMurrich's species; the latter we have been able to examine through the courtesy of our friend, and as he has not figured one of these bays we add one for comparison (Pl. LXIII., fig. 3).

Endoderm.—The endoderm of the body-wall presents few features worthy of remark. In *I. asymmetricus* we have found nematocysts smaller than those which occur in the ectoderm. Zooxanthellæ are present in the three species of Zoanthus from Torres Straits, and appear to be characteristic of this genus as well as Isaurus. They are also extremely numerous in *G. mutuki*, and are present in *Palythoa howesii* and *P. kochii.* In *Parazoanthus dixoni* the endoderm is thickened into ridges between the mesenteries, but in most cases it is of uniform thickness.

Diffuse endodermal muscle.—The base of the endoderm forms a feeble but complete muscular sheath; as the fibres run in a horizontal direction, the muscle is scarcely to be seen in transverse sections; in vertical sections (Pl. LIX., figs. 9 and 12) they are readily seen.

Sphincter muscle.—The diffuse endodermal muscle of the general body-wall becomes converted in the capitular region into a sphincter muscle, which in contraction causes the introversion of the corona and capitulum. The genus Parazoanthus is unique amongst the Zoantheæ in possessing an endodermal sphincter. This fact was first discovered by Erdmann (**1885**, p. 468), who made this a primary character in the definition of his interpretation of the genus Palythoa, of which he took *P. axinellæ* as the type. As we shall subsequently explain, Erdmann's genus Palythoa cannot stand; so we have erected the new genus of Parazoanthus in its

stead. The infoldings of the endodermal sphincter, especially in its upper portion, are frequently so cut across by the razor in sections as to appear isolated, and thus the muscle might be supposed to be partly mesoglœal in character (Pl. lx., fig. 8). It is possible that this may actually occur to a very slight extent. In either case the distinction between Zoantheæ with an endodermal and a mesoglœal sphincter is not so fundamental as might appear at first sight.

All other Zoantheæ have a mesoglœal sphincter. In Sphenopus the sphincter is extremely long, as Erdmann has previously remarked; Zoanthus alone has a double sphincter (Pl. lxiv., figs. 3 and 5).

Capitulum.—The capitulum, as all authors have described, is thrown into ridges; these have a certain amount of specific value, but too much reliance should not be placed upon this character.

In all species the ectoderm retains its character as a continuous epithelium. In *Z. coppingeri* the ridges are crowded with nematocysts, but we do not find this of common occurrence.

Tentacles.—The ectoderm of the tentacles contains numerous sausage-shaped nematocysts. The deeper layer of the ectoderm usually exhibits a well-marked nervous layer, the nerve-cells of which are shown in Pl. lxiv., fig. 2. There is a diffuse ectodermal muscular sheath, the fibres of which have a longitudinal direction.

The mesoglœa is usually thin. The endoderm is relatively thick; and in *Z. coppingeri*, *Z. jukesii*, and *Z. macgillivrayi* zooxanthellæ are here especially abundant, but in *I. asymmetricus* and in *Palythoa howesii* and *P. kochii*, although they are present in the endoderm of the body-wall, few, if any, are to be found in this region. In *Z. coppingeri* numerous nematocysts of oval shape, similar to those found in the ectoderm of the body-wall, are present in the endoderm of the tentacles (Pl. lxiv., fig. 2). And in some of our specimens of *E. couchii* similar nematocysts are to be found in the ectoderm of the tentacles. A diffuse endodermal muscular layer consisting of fibres which run in a circular or horizontal direction, and which may be regarded as an extension of the muscular layer of the body-wall, is found in the tentacles of all our species.

Disc.—The structure of the disc is usually similar to that of the tentacles. As in the latter, there are no incrustations.

Œsophagus.—The ectoderm of the œsophagus is usually more or less folded; but as the degree of folding is variable in different individuals of the same species, and probably also in the same individual in different conditions of contraction, this character is of little value for systematic purposes. The same may be said of the nature and extent of the groove. A sulcar groove is always present, but it is scarcely discernible in our specimens of *I. asymmetricus*, and in one of the specimens of *E. incrustatus* (Pl. lx., fig. 1). In other specimens of the latter species it is,

however, distinct. Nematocysts are found in the ectoderm of the œsophagus of *Palythoa cœsia* (?), *E. couchii*, and *E. arenaceus.*

The mesoglœa of the œsophagus is generally thin, but in many species of Epizoanthus and of Parazoanthus it is much thickened in the groove. Cell enclosures are generally absent in this region, but we have seen a few cell-islets in the mesoglœa of the groove of *P. anguicoma* (one specimen), and they are also present in that of *P. dichroicus.*

Mesenteries.—The mesenteries which are such a valuable aid to classification of the Actiniæ generally are arranged in this group in a very uniform manner, which we have already described.

Imperfect mesenteries.—The imperfect mesenteries vary in the extent to which they project into the cœlenteron. In *E. incrustatus*, and in *Parazoanthus douglasi* they are very small, whereas in *P. dixoni* they are well developed. When canals are present in the perfect mesenteries they are also to be found in the imperfect.

Perfect mesenteries.—There is no distinction between any of the perfect mesenteries.

Ectoderm.—The presence of ectoderm in certain mesenteries of the Anthozoa appears to be now fairly well established. E. B. Wilson (" Mesenterial Filaments of the Alcyonaria": Mitth. Zool. Stat. Neapel, v. 1884) came to the conclusion that the " dorsal " pair of filaments in the Alcyonaria were ectodermal in origin, but that the other six filaments were solely endodermal; these two kinds of filaments can be readily distinguished histologically. Some years previously von Heider (*Cerianthus membranaceus*, Haime: Sitz. kais. Acad. Wien, lxxix. 1879) believed, solely from a histological study of the adult Cerianthus, that the filaments of that form were ectodermal. The Brothers Hertwig (Die Actinien, 1879) pointed out that embryological deductions based on adult histology were not very reliable, and also brought forward, as an objection to von Heider's view, the existence of filaments on imperfect mesenteries in the Actiniæ generally. H. V. Wilson (Journ. Morph. II., 1888) has shown for the coral Manicina, and J. P. McMurrich (*ibid.* IV. 1891) for the Actinian, Rhodactis, that the mesenterial filaments are derived from the ectoderm of the œsophagus.

From the histological characters and absolute continuity of what we have termed the " reflected ectoderm " of the mesenteries with the ectoderm of the œsophagus on the one hand, and with the mesenterial filament (craspedum) on the other, we have no doubt as to the morphological identity of these tissues.

Reflected Ectoderm and Filaments.—The mesenteric ectoderm consists of two portions, an upper, which we speak of as the " reflected ectoderm," and a lower portion, which runs down the edge of the mesentery, and is known as the mesenterial filament, or " craspedum " of Gosse. These two are perfectly continuous with each other and with the ectoderm of the œsophagus.

In looking at a side view of a mesentery such as that of *Z. macgillivrayi* (Pl. LXIV., fig. 5) it will be seen that the ectoderm of the œsophagus passes continuously on to the mesentery where it suddenly becomes greatly thickened, and is thrown into transverse folds; the whole thickening has a crescentic form, first coming upwards and then downwards losing itself in the mesenterial filament. The ectoderm is reflected on both sides of every one of the perfect mesenteries (Pl. LX., fig. 6), and presents a very characteristic appearance in transverse sections (Pl. LXIV., figs. 4 and 6). The folds often present a pinnate appearance, but they are rarely accurately symmetrical on each side.

In some species the endoderm is implicated in the upward reflection of the lower edge of the œsophagus; this is especially noticeable in *Parazoanthus axinellæ* (Pl. LX., fig. 6), but it is not a feature of any morphological importance.

As above mentioned the reflected ectoderm passes gradually into the mesenterial filament. The characteristic trefoil (*P. axinellæ*) (Pl. LX., fig. 6) or V-shape (*Z. macgillivrayi*) (Pl. LXIV., fig. 7) of the latter in transverse sections is continuous with the peripheral pair of folds of the reflected ectoderm.

The lateral elements of the upper portion of the craspedum gradually become shorter, so that eventually only the median portion is left (Pl. LX., fig. 7). This transition takes place very shortly below the lower level of the œsophagus.

Nematocysts are numerous in the simple lower portion of the mesenterial filament; but they are not readily seen in the upper portion, and we have not observed any in the reflected ectoderm. Unicellular glands and pigment granules also occur in the filament.

The length of the craspeda varies even in the same genus, it apparently being dependent upon the height of the polyp; for example in *Z. jukesii*, which is a short species, the filaments extend nearly down to the commencement of the cœnenchyme, whereas in *Z. macgillivrayi* they cease about half way down the polyp.

Mesoglœa.—The mesoglœa of the mesenteries exhibits a certain amount of variation in thickness; for example, in the œsophageal region of *Parazoanthus dixoni* (Pl. LX., fig. 9), the mesoglœa is relatively thick, whereas in *Epizoanthus paguriphilus* (Pl. LX., fig. 5) it is quite thin.

Canals.—In describing the canals in the mesoglœa of the body-wall, we have already alluded to the fact that in the three species of the genus Zoanthus from Torres Straits which we have examined, they not only arise from the ectoderm, but pass into the mesenteries.

Hertwig (**1882**, p. 115) describes in *Z. danæ* (?) (*cf.* **1888**, p. 36) a basal "septal canal" "in the supporting lamella of the septa in immediate proximity to the wall." He "never could make out any connexion between this septal canal and the ectodermal cords [*i. e.* canal system] of the wall"; and he is

"inclined to believe that it is produced from the endoderm." His reason is that the zooxanthellæ, which are found in the mesenteric canal of this species, "force their way into the septal canal, but never into the canals of the wall." According to our experience there are no connexions between the canal-system of the body-wall and the mesenteric canals in the œsophageal region of the body, although they are numerous lower down. The section Hertwig figures is from the œsophageal region.

McMurrich (**1889** A, p. 64) finds in *Z. sociatus*, in "one mesentery, the basal canal communicating with one of the spaces in the mesoglœa of the column wall." He adds: "It seems open to question whether the cells of the larger cavities in the mesoglœa are not in reality endodermal in their origin." In his subsequently written, but previously published Paper (**1889**, p. 114), in alluding to the body-wall canals of *Z. flos-marinus*, he refers the reader to his description of *Isaurus* ["*Mammillifera*"] *tuberculatus* for his views as to the origin of these canals, evidently believing that the "endodermal bays" of the latter species give rise to some of the canals, the remainder being similarly derived from the ectodermal bays, and then not unnaturally concludes that the mesenteric canals are connected only with the endodermal "spaces" of the body-wall. We have corroborated McMurrich's observation as to the double origin of the canal-system in the body-wall of Isaurus; but we have no reason for supposing that the canals in the mesenteries are without exception of endodermal origin, although some undoubtedly are (Pl. LXIII., fig. 5). Our experience leads us to the conclusion that it is necessary to be cautious in arguing as to the origin of these canals from one genus to another. For confirmation of our view, that the mesenteric canals of Zoanthus are of ectodermal origin, we point to the demonstration of this fact for *Z. coppingeri* (Pl. LXII., fig. 1).

In *Z. coppingeri* the canals form at the base of each mesentery a large sinus, which extends up the mesentery, nearly to the generative region, where it rapidly narrows, and extends right up the mesentery as the "basal canal." In *Z. jukesii* and in *Z. macgillivrayi* the mesenteric canals are present, though not forming extensive sinuses (Pl. LXII., fig. 2).

In *I. asymmetricus* the canal system appears in sections as if broken up into lacunæ; but it may really form a continuous system of anastomosing canals.

In *Gemmaria rusei* (**1889**, p. 125) and *G. isolata* (**1889** A, p. 66) the mesenteric canal, according to McMurrich, has the character of a basal canal. We find the same in our two species. Sinuses, extending throughout the whole length of the mesenteries, occur in the three species of Palythoa we have examined. So far as our experience goes canals are absent from the mesenteries of Epizoanthus, and the same obtains for all the species of Parazoanthus except *P. anguicoma* and *P. dixoni*, in which species we have found sinuses in the bases of the mesenteries which have a slight vertical extension.

In *Parazoanthus dichroicus* cell-islets occur in the mesoglœa of the mesenteries, and also in *E. paguriphilus.*

Nematocysts are sometimes present in the canals and sinuses of the mesenteries (*e.g. Z. coppingeri* (Pl. LXII., fig. 1) and *Palythoa howesii*); but zooxanthellæ are rarely present. We have found them in *Palythoa kochii.*

Endoderm.—The endoderm of the proximal portion of the mesenteries usually resembles that of the body-wall, except that it more frequently contains nematocysts, as in *Z. coppingeri*, *Z. macgillivrayi*, and *I. asymmetricus.* In the latter species they are much smaller than those of the ectoderm of the body-wall. Zooxanthellæ occur in the endoderm of the mesenteries in those species in which they are present in the general endoderm.

McMurrich has carefully described the swollen distal portion of the endoderm of the mesenteries of *Z. flos-marinus* (**1889**, p. 115, Pl. vii., fig. 4) in that region of the body where the mesenterial filament is simple. We have found a similar enlargement in *Z. macgillivrayi* (Pl. LXIV., fig. 8), in which nematocysts are present. Our specimen differs from his chiefly in the possession of zooxanthellæ and nematocysts; we have not observed in our species that these endodermal cells are "loaded with green granules, closely packed together."

A similar swelling occurs, to a variable extent, in other species; for example, in *P. axinellæ* (Pl. LX., fig. 7) it is only moderately developed, and we have not observed nematocysts or zooxanthellæ; but these appear to be absent in the general endoderm of this species. Sometimes the swelling is absent, as in *E. incrustatus.*

We, too, have found, with McMurrich, "foreign bodies of organic nature imbedded in the cells, sometimes being surrounded by a number of cells containing no granules, or occasionally imbedded in the mesoglœa" (**1889**, p. 116). He suggests that these are concerned with digestion (Pl. LXIV., fig. 8).

Muscles.—The muscles of the mesenteries are endodermal and diffuse. As in other Actiniæ there are two kinds of muscles, the longitudinal and the parieto-basilar.

The longitudinal muscle is often very difficult to distinguish in transverse section, being feebly developed, and forming a simple layer of fibres (Pl. LXIV., fig. 8). In *I. asymmetricus* and *E. paguriphilus*, *Parazoanthus dixoni*, and others, the muscle is better developed, and is slightly plaited (Pl. LX., fig. 9).

The parieto-basilar muscle is usually relatively broader, and extends higher up the mesenteries than in other Actiniæ; but in *Parazoanthus anguicoma* and *P. dixoni*, this muscle is very feebly developed, and only occurs at the insertion of the mesenteries (Pl. LX., fig. 9).

It has been recognized by other investigators that judging by the arrangement of the muscles the mesenteries of the Zoantheæ are paired, although the

two elements of each pair are respectively a perfect and imperfect mesentery, and are independently developed. Recently, however, Danielssen (1890) has thrown doubt upon this paired arrangement, since he finds in the various species he has examined that the muscles are equally developed on both sides of the perfect mesenteries. Owing to the kindness of our Norwegian colleague we have been enabled to examine some specimens of *Epizoanthus* [" *Mardœll* "] *erdmanni*, and our sections show this paired arrangement quite clearly.

Gonads.—There appears to be a general impression that all the Zoantheæ are hermaphrodite. This is certainly not the case in four genera; of one genus we have no facts either way, and in the the remaining two genera the sexes may be distinct or united. Generative organs often appear to be absent in specimens of Zoantheæ, but we have been somewhat fortunate in finding them in those we have examined. Their mode of occurrence will be seen on reference to the Plates in this and in the Memoir on the Zoantheæ from Torres Straits.

Erdmann found that the two species of Zoanthus which he examined (" 1 sp. Zoanthus sp. ?," p. 438 (= *Z. danæ* [?], Hertwig); and "2 sp. Z. sp. ?," p. 447) were hermaphrodite, so he concluded that this was a generic character. McMurrich found no generative organs in the two species he examined. Of the three species we have examned, two specimens of *Z. coppingeri* were male and three were female; two specimens of *Z. jukesii* were female, and of the four specimens of *Z. macgillivrayi* we sectionized none were fertile. The conclusion we arrive at is that the genus is as often diœcious as monœcious.

McMurrich found that *Isaurus* [" *Mammillifera* "] *tuberculatus* was hermaphrodite, and owing to his courtesy we have been enabled to verify this fact. We have cut several specimens of our *I. asymmetricus*, but in only one of them could we discover generative organs, and in this case they were feebly developed ova. We cannot, however, assume that the genus is hermaphrodite because one species is undoubtedly monœcious.

All the remaining genera, so far as is known, are diœcious, except Sphenopus, the gonads of which are unknown.

Neither Erdmann nor McMurrich found generative organs in the five species of Palythoa (" Corticifera ") examined by them. We have been more fortunate, since in *P. kochii* we found male organs alone, and in *P. howesii* we found only female.

According to our experience all the members of a single colony of diœcious Zoantheæ belong to the same sex; but we cannot lay down any general rule on this point.

Cœnenchyme.—The structure of the cœnenchyme is similar in every respect to that of the polyps. The only difference consists in the presence of cœlenteric canals, which are merely prolongations of the cœlenteron of the polyps.

The cœnenchyme may occur as stolons, more or less riband-like, or as flattened expansions, or, as in Palythoa, it may fill up the intervals between the polyps. Some zoologists have laid stress on the systematic value of the habit of growth of the cœnenchyme; but, as a matter of fact, we have often found that in the same species it varies according to the surface to which the colony is attached, and therefore cannot lay great stress on this character. The genus Gemmaria, as defined by M^cMurrich, precisely resembles Palythoa (his Corticifera), with the exception of the character of the cœnenchyme, it being absent or lamellar in the former. We consider this a legitimate use of the character of the cœnenchyme for taxonomic purposes.

The most interesting varieties of cœnenchyme occur amongst those species of Epizoanthus which incrust Gasteropod shells inhabited by hermit crabs. In these cases the cœnenchyme dissolves the lime of the shells, which it replaces by its own substance; and thus the carcinæcium practically forms an isomorph of the shell. The spire of the shell is the last portion to be absorbed. In describing the manner in which the polyps are arranged on the cœnenchyme, we employ the terms "dorsal," "ventral," "anterior," "posterior," "right," and "left;" these have reference solely to the position of the carcinæcium with regard to the crab when walking.

Development.—We have no account of the development of any Zoanthean, with the possible exception of an observation by Van Beneden (**1890**), who describes the anatomy of a larval Actinozoon allied to Semper's larva (Zeitschr. f. wiss Zool., xvii. 1867). He regards it as a larva of a "microtypal" (brachycnemic) Zoanthean, on account of the arrangement of the mesenteries. He adds: "What further confirms our opinion, that our larva and that of Semper may be connected with the development of the Zoantheæ, is that the constitution of the mesenchymatous lamella is particularly well developed, and provided with numerous cellular elements, of which some have an endodermic origin, the others being derived from the ectoderm" (p. 95). The senior author has very recently (Proc. Roy. Dub. Soc. (N. S.), vol. vii., pt. III., p. 127, 1891) published a small Paper on a larval stage of the coral Euphyllia, which presents many of the anatomical peculiarities which characterise Van Beneden's larva; it is only fair to add that in the newly-hatched larva of Euphyllia the mesoglœa is thin and without cell-enclosures.*

Parasites.—Some of our specimens of *Parazoanthus douglasi* from Albany Pass are infested by a Copepod which deposits its egg-capsule in the cœlenteron or

* Since the above was in type we have received, through the courtesy of the author, a valuable Paper on "The Phylogeny of the Actinozoa," by Professor M^cMurrich (**1891**), in which he gives an account, and four figures (Pl. IX., figs. 5–8), of two stages in the development of a brachycnemic Zoanthean. We regret we can do no more than draw attention to this Paper.

cœlenteric canals of the Zoanthean. The capsules are paired, and contain a large number of ova. We have these in the nauplius stage, and in other stages of development. We have two specimens of the Copepod, but are unable to say whether these are adult or not. The capsules form distinct swellings (Pl. LXI., figs. 19–22) of the body-wall of the Actinian. This fact leads us to suppose that the Copepod remains within the cœlenteric cavities while the capsule is developing; and when the latter is ripe it breaks away from it.

We have sections of a Crustacean in the cœlenteron of the only specimen of *Epizoanthus macintoshi* (from Shetland) we were able to cut, but we cannot say anything more about it.

Small, oval, deeply pigmented bodies occur in many parts of the body in *Parazoanthus dichroicus* and in *P. douglasi* (Pl. LXII., figs. 5 and 6). They are evidently parasites, but we have been unable to determine their nature.

Problematical rounded bodies, which stain deeply and uniformly with carmine, are present in *Z. macgillivrayi*, *Palythoa howesii*, and other species.

CLASSIFICATION OF THE GROUP.

ZOANTHEÆ.

Actiniæ with numerous perfect and imperfect mesenteries, and two pairs of directive mesenteries, of which the sulcar are perfect and the sulcular are imperfect. A pair of mesenteries occur on each side of the sulcular directives, of which the sulcular moiety is perfect and its sulcar complement is imperfect; a similar second pair occurs in one section of the group (Brachycneminæ), or the second pair may be composed of two perfect mesenteries (Macrocneminæ). In the remaining pairs of mesenteries, of both divisions, this order is reversed, so that the perfect mesentery is sulcar and the imperfect is sulcular. The latter series of mesenteries are bilateral as regards the polyp and arise independently (*i. e.* neither in pairs nor symmetrically on each side) in the exocœle on each side of the sulcar directives, in such a manner that the sulcular are the oldest and the sulcar the youngest. Only the perfect mesenteries are fertile or bear mesenterial filaments. A single sulcar œsophageal groove is present. The mesoglœa of the body-wall is traversed by irregularly branching ectodermal canals or by scattered groups of cells. The body-wall is usually incrusted with foreign particles. The polyps are generally grouped in colonies connected by a cœnenchyme, the cœlenteron of each polyp communicating with that of the other members of the colony by means of basal endodermal canals.

Family. ZOANTHIDÆ, Dana, 1846.

(With the definition of the group.)

Sub-family. BRACHYCNEMINÆ, n. s.-f.*

Zoantheæ in which the sulcar element of the primitive sulco-lateral pair of mesenteries (cnemes) is imperfect:—

GENERA AND TYPE SPECIES.

ZOANTHUS,	Lamarck.	Type *Z. sociatus* (Ellis).
ISAURUS,	Gray.	,, *I. tuberculatus*, Gray.
(? MAMMILLIFERA,	Lesueur.	,, *M. auricula*, Lesueur.)
GEMMARIA,	Duchassaing et Michelotti.	,, *G. rusei*, Duch. and Mich.
PALYTHOA,	Lamouroux.	,, *P. mammillosa* (Ellis and Sol.).
SPHENOPUS,	Steenstrup.	,, *S. marsupialis*, Steenstr.

* βραχύς, short; μακρός, long; κνήμη, a radius or spoke of a wheel. We have tried hard to discover a short term for a mesentery, which would readily lend itself to combination with other words, but without

Sub-family. MACROCNEMINÆ, n. s.-f.*

Zoantheæ in which the sulcar element of the primitive sulco-lateral pair of mesenteries (cnemes) is perfect :—

GENERA AND TYPE SPECIES.

EPIZOANTHUS, Gray.	Type *E. incrustatus* (Düb. and Kor.).
PARAZOANTHUS, n. g.	,, *P. axinellæ* (Schmidt).

The Zoantheæ constitute a very well-marked division of the Actiniæ; no connecting forms between these and any other group are known.

The classification of the Zoantheæ proposed by Erdmann has been adopted by all subsequent writers; and as his was the first which was based on internal anatomy, we need not enter into a discussion of the earlier systems.

Erdmann adopts Andres' two families, the Zoanthidæ and the Sphenopidæ, with the following definitions :—" Zoanthidæ : Zoantheen, welche durch ein Cœnenchym zu Colonien vereinigt werden ;" and " Sphenopidæ: Einzellebende Zoantheen, welche mit ihren abgerundeten Körperende im Sande stecken oder mit einer Art Haftscheibe am Boden festsitzen." It is strange that these families should be based solely upon the habit of growth. In the second family he places Sphenopus and his " genus novum " ; the latter is undoubtedly the free (or Sidisia) variety of an Epizoanthus. It is very probable that this is really the free-variety of the type species of Epizoanthus (*E. incrustatus*). As this form passes out of the family we see no reason for retaining a family for Sphenopus, especially as an isolated mode of growth occurs in the other family, as McMurrich has shown that *Gemmaria rusei* is "solitary, being attached to pebbles without the development of any cœnenchyme" (**1889**, p. 124), and the individuals of his *G. isolata* " were scattered and buried up to the tentacles in the sand" (**1889** A, p. 65); and it is characteristic of the genus Isaurus for the polyps to be either solitary, or in small groups with a feeble cœnenchyme. We therefore think it preferable to base divisional characters on anatomical differences.

McMurrich has adopted Andres' three divisions, the third being the Bergidæ. As nothing is known about the structure of the latter we think it better to omit them altogether.

success. The objection to the word " cneme " is that it has reference to the appearance of a transverse section of an Actinian rather than to a mesentery as it actually exists. As the investigation of the Zoantheæ, at least, must principally be made by means of transverse sections, this objection has not much weight.

* *Ibid.*

We acknowledge only one family in the group which we divide into two sub-families, the Brachycneminæ, and the Macrocneminæ, which are based upon the two well-known types of mesenterial arrangement. It is worthy of notice that, so far as our knowledge at present extends, the Macrocneminæ alone are represented in the North Atlantic, although they are world-wide in distribution.

The following Table shows the chief generic distinctions at a glance, and demonstrates that the group is a very homogeneous one. We regard Parazoanthus as being the least specialised genus on account of its having a single endodermal sphincter muscle, and Zoanthus as the most specialised, as it possesses a double mesoglœal sphincter muscle. We omit Mammillifera, as the type species have never been described from an anatomical point of view:—

Genus.	Mesenterial arrangement.	Sphincter.	Gonads.	Body-wall and Cœnenchyme.
Zoanthus.	Brachycnemic.	Double mesoglœal.	⚥ or ♂, ♀	Unincrusted; well-developed ectodermal canal system.
Isaurus.	Brachycnemic.	Single mesoglœal.	⚥ or ♂, ♀	Unincrusted; ectodermal and endodermal bays and small canals; sometimes solitary.
Gemmaria.	Brachycnemic.	Single mesoglœal.	♂, ♀	Incrusted; lacunæ; often solitary, always attached.
Palythoa.	Brachycnemic.	Single mesoglœal.	♂, ♀	Similar to above, but polyps immersed in expanded cœnenchyme.
Sphenopus.	Brachycnemic.	Single mesoglœal.	?	Incrusted; cell-islets; always solitary and free.
Epizoanthus.	Macrocnemic.	Single mesoglœal.	♂, ♀	Incrusted; cell-islets.
Parazoanthus.	Macrocnemic.	Endodermal.	♂, ♀	Incrusted; ectodermal canals; cell-islets; encircling sinus; ectoderm always continuous.

In the following list we have enumerated immediately after the generic description all the species which can be definitely referred to any species, adding in brackets [ ] the initials of the zoologists who have investigated those forms, and on whose authority the generic allocations are made. The initials are as follows:—A., Andres; E., Erdmann; E. & H., Erdmann and Hertwig, for those species described in the Supplement to Hertwig's "Challenger" Report, 1888, the anatomical work on the Zoantheæ being done by Erdmann; H., Hertwig (1882); H. & S., Haddon and Shackleton; M., McMurrich. Although other zoologists have made anatomical investigations on some forms, yet in no other case is there sufficient information given to enable one to determine the generic position of a particular species.

In a few instances we have added those species which we think may safely be regarded as probably belonging to a particular genus, *e.g.* Palythoa and those species of Epizoanthus which form carcinæcia, owing to their having a similar habit of growth to species whose genus is known. Beyond this we have not dared to go, as enough confusion has been made in the group without our gratuitously adding to it.

Family. ZOANTHIDÆ.

Sub-family. BRACHYCNEMINÆ.

ZOANTHUS, Lamarck, 1801.

Brachycnemic Zoantheæ, with a double mesoglœal sphincter muscle. The body-wall is unincrusted; the ectoderm is usually discontinuous; well-developed ectodermal canal system in the mesoglœa. Monœcious or diœcious. Polyps connected by thin cœnenchyme.

RECOGNIZED SPECIES.

Z. sociatus (Ellis), 1767.—Dominica, Barbadoes, Guadeloupe, Bahamas, [M.].
Z. flos-marinus, Duch. & Mich., 1860.—St. Thomas, Bermudas, [M.].
Z. danæ (?), of Hertw., 1888.—Bermudas (? if the same as *Z. danai*, Le Conte, 1851, Panama), [E. & H.].
Z. confertus, of Hertw., 1888.—Cape of Good Hope (? if the same as *M. conferta*, Verrill, 1868, San Salvador, Acapulco), [E. & H.].
Z. coppingeri, Hadd. & Shackl., 1891.—Torres Straits, [H. & S.].
Z. jukesii, Hadd. & Shackl., 1891.—Torres Straits, [H. & S.].
Z. macgillivrayi, Hadd. & Shackl., 1891.—Torres Straits, [H. & S.].
Z. sp. (?), Hertw., 1882.—Bermudas, [H.].

ISAURUS, Gray, 1828.

Large brachycnemic Zoantheæ, with a single mesoglœal sphincter muscle. The body-wall is unincrusted; the ectoderm is discontinuous; ectodermal and endodermal bays and small canals in the mesoglœa. Monœcious or diœcious. Polyps in small clusters or solitary.

RECOGNIZED SPECIES.

I. tuberculatus, Gray, 1828.—Guadeloupe, Bermudas, [M.].
I. spongiosus (Andres), 1877.—Port Natal, [A.].
I. asymmetricus, Hadd. & Shackl., 1891.—Torres Straits, [H. & S.].

PROBABLY BELONGING TO THIS GENUS.

I. cliftoni (Gray), 1867.—W. Australia.

[? MAMMILLIFERA,* Lesueur, 1817.

M. auricula, Lesueur, 1817.—St. Vincent; Dominica.
M. nymphœa, Lesueur, 1817.—St. Christopher.]

GEMMARIA, Duchassaing et Michelotti, 1860.

Solitary brachycnemic Zoantheæ, with a single sphincter mesoglœal muscle. The body-wall is incrusted with particles of sand. The ectoderm is usually discontinuous, but may be continuous. Lacunæ and cell-islets are found in the mesoglœa. Diœcious.

RECOGNIZED SPECIES.

G. rusei, Duch. & Mich., 1860.—St. Thomas, Bermudas, [M.].
G. isolata, McMurr., 1889.—Bahamas, [M.].
G. macmurrichi, Hadd. & Shackl., 1891.—Torres Straits, [H. & S.].
G. mutuki, Hadd. & Shackl., 1891.—Torres Straits, [H. & S.].

PROBABLY BELONGING TO THIS GENUS.

G. philippinensis (Gray), 1867.—Philippines.

* The position of this genus cannot be settled until the type species have been recovered and sectionized.

PALYTHOA, Lamouroux, 1816.

Brachycnemic Zoantheæ, with a single mesoglœal sphincter muscle. The body-wall is incrusted; the mesoglœa contains numerous lacunæ, and occasionally canals. Diœcious. Polyps immersed in a thick cœnenchyme.

RECOGNIZED SPECIES.

P. mammillosa (Ellis & Sol.), 1786.—Jamaica, = *Corticifera lutea* of Hertwig, 1888.—Bermudas, probably not *C. lutea,* Quoy & Gaim., 1833.—Tongatabou, [E. & H.].
P. ocellata (Ellis & Sol.), 1786.—Dominica, Jamaica, [M.].
P. glareola (Lesueur), 1817.—Guadeloupe, Bermudas, [M.].
P. flava (Lesueur), 1817.—St. Thomas, Bahamas, [M.].
P. tuberculosa, of Hertwig, 1888.—Cape of Good Hope; probably not *P. tuberculosa,* Klunz., 1877.—Red Sea, [E. & H.].
P. howesii, Hadd. & Shackl., 1891.—Torres Straits, [H. & S.].
P. kochii, Hadd. & Shackl., 1891.—Torres Straits, [H. & S.].
P. cæsia ?, Dana (*fide* H. & S., 1891).—Torres Straits, [H. & S.].

THE FOLLOWING PROBABLY BELONG TO THIS GENUS:—

P. aggregata (Lesson.), 1830.—Society Archipelago.
P. lutea (Quoy & Gaim.), 1833.—Tongatabou.
P. flavo-viridis, Ehr., 1834.—Red Sea.
P. argus, Ehr., 1834.—Red Sea.
P. cæsia, Dana, 1846.—Fiji.
P. glutinosa, Duch. & Mich., 1866.—St. Thomas, probably = *P. ocellata,* (E. & S.).
P. caribæorum, Duch. & Mich., 1866.—St. Thomas.
P. cinerea, Duch. & Mich., 1866.—St. Thomas.
P. tuberculosa, Klunz., 1877.—Red Sea. Probably neither of Hertwig nor of Studer, 1878.—New Ireland.
P. calcaria, Müll., 1883.

SPHENOPUS, Steenstrup, 1856.

Free solitary brachycnemic Zoantheæ, with a single, very long mesoglœal sphincter muscle. The body-wall is incrusted. Cell-islets are present in the mesoglœa.

RECOGNIZED SPECIES.

S. marsupialis, Steenstr., 1856.—Tranquebar, Pulo Faya, China Seas, Gray; (? Madras, H. & S.), [H. & S.].
S. marsupialis, var. *bursiformis*, Gray, 1867.—Massachusetts Bay, N. America. (This requires confirmation.)
S. arenaceus, Hertw., 1882.—Cape York, [H.].
S. pedunculatus, Hertw., 1888.—Philippine Islands, [E. & H.].

Sub-family. MACROCNEMINÆ.

EPIZOANTHUS, Gray, 1867.

Macrocnemic Zoantheæ, with a single mesoglœal sphincter muscle. The body-wall is incrusted. The ectoderm is usually continuous, but may be discontinuous; cell-islets in the mesoglœa. Diœcious polyps, connected by cœnenchyme, which may be band-like, incrusting, or greatly reduced, as in the free forms.

RECOGNIZED SPECIES.

E. incrustatus (Düb. & Kor.), 1847.—Norway, [H. & S.], = *E. papillosus* (Johnst.), 1842.—W. coast of Britain, [H. & S.], = *Sidisia barleei*, Gray, 1858 (free variety).—Shetlands, [H. & S.], = *E. americanus*, Verr., 1864 (and free variety).—E. coast of N. America, [H. & S.], = *E. cancrisocius* of Hertw. (not of Studer), 1888.—Nova Scotia, [E. & H.].
E. arenaceus (D. Ch.), 1836.—Mediterranean, [H. & S.].
E. couchii (Johnst.), 1838.—S. W. Britain, [H. & S.].
E. norvegicus (Kor. & Dan.), 1877.—Norway, [H. & S.].

E. paguriphilus, Verr., 1882.—E. coast of N. America; W. coast of France; W. coast of Ireland, [H. & S.].

E. parasiticus, of Hertw., 1882.—Japan (probably not of Verrill, 1862), [H.].

E. thalamophilus, Hertw., 1888.—Valparaiso, [E. & H.].

E. stellaris, Hertw., 1888.—Philippines, [E. & H.].

E. elongatus, Hertw., 1888.—Monte Video, [E. & H.].

E. erdmanni (Dan.), 1890.—N. coast of Norway; Spitzbergen, [H. & S.].

E. macintoshi, n. sp.—Shetlands, [H. & S.].

E. wrightii, n. sp.—Dublin Bay, [H. & S.].

PROBABLY BELONGING TO THIS SPECIES.

E. cancrisocius (Martens), 1875, ? of Studer, 1878.—Japan.

E. parasiticus, Verr., 1864.—E. coast of N. America.

E. abyssorum, Verr., 1885.—E. coast of N. America.

E. eupaguri (Mar.), 1882.

PARAZOANTHUS, n. g.

Macrocnemic Zoantheæ with a diffuse endodermal sphincter muscle. The body-wall is incrusted; the ectoderm is always continuous; the mesoglœa contains ectodermal canals, cell-islets, and an encircling sinus. Diœcious.

RECOGNIZED SPECIES.

P. axinellæ (Schmidt), 1862.—Mediterranean, [E.], [H. & S.].

P. anguicoma (Norm.), 1868.—Shetlands; W. Britain, [H. & S.].

P. dixoni, n. sp.—W. of Ireland, [H. & S.].

P. dichroicus, H. & S. 1891.—Torres Straits, [H. & S.].

P. douglasi, H. & S., 1891.—Torres Straits, [H. & S.].

P. (sp.)? (Hertw.), 1888.—Tristan d'Acunha, [E. & H.].

P. hertwigi, n. n.—Tristan d'Acunha, [E. & H.], name proposed by us (see p. 616) for *P. anguicoma*, of Hertwig, 1888.

SYSTEMATIC ACCOUNT OF THE BRITISH ZOANTHEÆ.

ZOANTHIDÆ.

I. BRACHYCNEMINÆ. (None British.)

II. MACROCNEMINÆ.

EPIZOANTHUS, Gray, 1867.

SPONGIA (pars), Johnston, 1834.
DYSIDEA ? (pars), Johnston, 1842.
MAMMILLIFERA (pars), Auct.
ZOANTHUS (pars), Auct.
SIDISIA, Gray, 1858.
CAROLIA, Gray, 1867.
POLYTHOA (pars), Andres, 1884.
PALYTHOA (pars), Carus, 1884.

Macrocnemic Zoantheæ, with a single mesoglœal sphincter muscle. The body-wall is incrusted; the ectoderm is usually continuous, but may be discontinuous; cell-islets in the mesoglœa. Diœcious. Polyps connected by cœnenchyme, which may be band-like, incrusting, or greatly reduced as in the free forms.

The genus Epizoanthus was established by Gray in 1867 for incrusted Zoantheæ: "II. coral attached; cells arising from a foliaceous expanded base. . . . The base expanded foliaceous (parasitic on shells); the cells cylindrical, simple, separate from each other from the base; tentacles numerous" (p. 237). *E. papillosus*, Johnst., is his type. Verrill adopted Gray's genus. At first Hertwig (**1882**) agreed with Verrill in using this term to denote incrusted forms which rose above their cœnenchyme. After Erdmann's investigations, he (**1888**) restricted the genus to macrocnemic Zoantheæ, with "Integument incrusted, cœnenchyme (mostly ?) lamellar; sphincter simple, mesoglœal; mesenteries arranged on the macrotype; colonies (mainly ?) parasitic" (p. 37). We have studied the type species of this genus, and find that it does conform to Erdmann's and Hertwig's definition of the genus. We may add that all observers have agreed in relegating to this genus all those incrusted Zoantheæ which form carcinæcia.

In 1858 Gray erected the genus Sidisia for free Zoantheæ, "which may be characterized by the emission of buds on the surface of the cylindrical body" (p. 532), *S. barleei* being the sole species. He considered that this species "evidently belongs to quite a different group" from *Dysidea papillosa*, Johnst., which Mr. Barlee (*in litt.*) informed Gray "was a Zoanthus, allied to the genus Mammillifera of Lesueur," an opinion which Gray adopted.

Our investigations prove that *S. barleei* is only a variety of *E. incrustatus* (= *E. papillosus*). We do not propose to keep the name Sidisia for the genus, although it has priority, and for this reason: it was solely erected for a species which is only

a variety of an older form; and the name has only been occasionally retained for this variety of that particular species, whilst Epizoanthus has been universally adopted for the more typical forms of this genus. Both names were originated by Gray, and we have therefore less hesitation in keeping to the latter.

Erdmann examined some free Zoantheæ which were dredged by "H. M. S. 'Triton,' 640 Fuss" (**1885**, p. 481). Without paying any attention to the literature of the subject, he relegated these to a new genus, which he did not name. Very likely it is the Shetland species. Danielssen (**1890**) described specimens which he referred to Erdmann's new genus, which he named Mardœll; and he called his new species *M. erdmanni* (p. 117). Through the courtesy of Dr. Danielssen we have been able to examine this form, and have cut sections of it. We are perfectly satisfied as to its specific distinction from the free variety of *E. incrustatus*.

The imperfect mesenteries of *E. erdmanni* are much more developed than in *E. incrustatus;* and there is almost invariably a well-marked lacuna in the mesoglœa at the base of the insertion of each mesentery.

In every respect it is an Epizoanthus, the sphincter being mesoglœal instead of endodermal, as Danielssen states, and the arrangement of the mesenteries is macrocnemic, though Danielssen's figures do not show this.

BRITISH SPECIES OF THE GENUS EPIZOANTHUS.

E. incrustatus, Düb. & Kor., 1847.	**E. paguriphilus**, Verr., 1882.
E. couchii, Johnst., 1838.	**E. macintoshi**, n. sp.
(**E. rubricornis**, Holdsw., 1861.)	**E. wrightii**, n. sp.

SYNOPSIS OF BRITISH SPECIES OF EPIZOANTHUS.

Forming carcinæcia, .	One polyp ventral, remainder marginal, . . .	*E. paguriphilus.*
	Polyps on upper surface only, ...	*E. incrustatus.*
Free olonies, . . .	Polyps radiating in one plane from a common point; diameter to height of polyp as 1 to 2, .	
	Polyps radiating in all directions from a common point; diameter to height of polyp as 1 to 4, .	(*E. rubricornis.*)
Incrusting Colonies, .	*a.* Cœnenchyme usually band-like, ...	*E. couchii.*
	Diameter to height of polyp as 1 to 4, . . .	(S. W. Ireland.)
	,, ,, ,, as 1 to 3, . . .	(S. W. England.)
	Cœnenchyme probably band-like; diameter of polyp nearly as great as height, ...	*E. macintoshi.*
	b. Cœnenchyme irregular; diameter of polyp greater than height, ...	*E. wrightii.*

The above relative proportions of diameter to height refers solely to contracted spirit specimens.

Epizoanthus incrustatus (Düb. and Kor.).

(Pl. LVIII., figs. 1–22; Pl. LIX., fig. 2; Pl. LX., fig. 1.)

Spongia suberia:

Johnston, 1834, Loudon's Mag. Nat. Hist., VII., p. 431, fig. 60.

Dysidea (?) *papillosa:*

Johnston, 1842, Hist. Brit. Sponges, pp. 190, 251 (in part), fig. 18 (not pl. xvi., figs. 6, 7), Gray, 1858, Proc. Zool. Soc., p. 531.

Mammillifera incrustata:

Düben and Koren, 1847, Forhandl. Skand. Naturf. Möde, p. 268 (*cf.* transl. in Isis, 1848, p. 536). Sars, 1851, Reise i Lofot. og Finm., Nyt Mag. Naturvid., VI. (2), p. 142. Danielssen, 1859, Nyt Mag. Naturvid., XI. (1861), p. 45.

Sidisia barleei:

Gray, 1858, Proc. Zool. Soc., XXVI., p. 532, pl. x., fig. 8. Gray, 1867, Proc. Zool. Soc., p. 237. Norman, 1868, Rep. Brit. Assoc. Adv. Sci., p. 319.

Zoanthus couchii:

(Not of Couch). Landsborough (in part), 1852, Brit. Zooph., p. 225. Holdsworth (in part), 1858, Proc. Zool. Soc., p. 557, pl. x., fig. 3; and 1859, Ann. Mag. Nat. Hist., (3), IV., p. 152. Var. *diffusa*, Gosse, 1860, Brit. Sea Anemones, p. 298, pl. IX., fig. 10; and var. *liber*, p. 298, pl. IX., fig. 9. Var. *M. incrustata*, Alder, Trans. Tyneside Nat. Field Club, V.

Zoanthus incrustatus:

Sars, 1860, Forhandl. Vidensk., Christiania, p. 141; also Forhandl. Skand. Naturf. Möde. Kjöb., VIII., p. 691. Norman, 1868, Rep. Brit. Assoc. Adv. Sci., p. 319.

Epizoanthus americanus:

Verrill, 1864, Mem. Boston Soc. Nat. Hist., I., pp. 34, 45 (addenda); 1866, Proc. Boston Soc. Nat. Hist., X., p. 335 (*Gemmaria americana*, Verrill, Am. Nat., II., p. 9, fig. 42); 1871, Am. Jour. Sci., II., p. 361. Dana, 1872, Corals and Coral Islands (2nd ed.), p. 62, figs. 1, 2. Verrill, 1873, U. S. Fish. Com. Rep., pp. 446, 510, pl. XXXVIII., figs. 286, 287; 1874, Am. Jour. Sci., VII., p. 413; *ibid.* (3), XXIII., 1882, p. 316. Smith and Harger, 1874, Trans. Connect. Acad., III., pp. 9, 10, 11, 55, pl. VIII., fig. 2. Verrill, 1883, Bull. Mus. Comp. Zool., XI., 1883–1885, p. 60, pl. VIII., figs. 1, 6; 1885, U. S. Fish. Com. Rep. (1883), p. 534.

Epizoanthus papillosus:

Gray, 1867, Proc. Zool. Soc., 1867, p, 237. Ridley, 1886, Proc. Roy. Irish Acad. (2), IV., No. 5, Sci., p. 617.

Palythoa arenacea:

Carus, 1884 (not of D. Ch.), Prod. Faunæ Medit., p. 75.

Polythoa arenacea:

Andres, 1884 (not of D. Ch.), Le Attinie, p. 308. Pennington, 1885, Brit. Zooph., p. 182.

Epizoanthus cancrisocius:

Hertwig (not of Studer), 1888, Zool. Voy. "Challenger," Rep. Actiniaria, Suppl. LXXIII. p. 41, pl. I., fig. 15.

Polythoa incrustata:

Bourne, 1890, Journ. Marine Biol. Assoc., I., p. 319.

Form.—Thickly incrusted forms, of which the well-grown polyps are twice as high as broad. Two well-marked varieties:—A. Incrusting form, cœnenchyme forming carcinæcia by replacement of a gasteropod shell; the two primary polyps at each end of the shell, usually forming a well-marked posterior marginal row of polyps; other polyps scattered on dorsal surface; maximum number about 10–12, varying much in height; no polyps on the under surface of the carcinæcium. B. Free form, primarily consisting of two individuals base to base, each of which may divide more or less regularly, or one only may divide.

Colour.—Sandy.

Dimensions.—Polyps, 3–9 mm. in height; 1·5–4·5 mm. in average diameter. Colonies, greatest length, 22–35 mm.; greatest breadth, 13–20 mm.

Locality.—Shetlands; W. and S. W. Ireland; N. E. England; Lerwick (Barlee); 30 miles E. and N. of Brassey I., 70–80 faths. (Barlee); Haaf, Shetland, 1863 (A. M. N.); 5–8 miles E. of Balta, Shetland, 40–50 faths., July 20–23, 1867 (A. M. N.), "commensal with *Pagurus lævis*" (Pl. LVIII., figs. 1–13); also in St. Magnus Bay (A. M. N.); 40 miles S. W. of Cape Clear, Co. Cork, 80–90 faths., 1885, commensal with *Eupagurus excavatus* and *Spiropagurus lævis* (A. C. H.); Nymph Bank, Co. Cork, 50 faths., 1886 (A. C. H.); Clew Bay, 1890; 33–40 faths. off Aran, Co. Galway, 1891 (A. C. H.), (Pl. LVIII., figs. 14–22); 33–36, Donegal Bay, 1891 (A. C. H.); Scarborough (Bean, *f.* Johnston); Northumberland, "deep water" (Alder); 48° 59′ 42″ N., 10° 7′ 27″ W., 90 faths., 1889 (G. C. Bourne), associated with *E. meticulosus;* Plymouth Sound (specimens in Mus. of Marine Biol. Assoc. Laboratory).

The geographical distribution of this species is North Atlantic, extending from the east coast of N. America to N. W. Europe.

The synonymy of this species is much involved, but we think the foregoing list is sufficiently complete. We agree with Norman in rejecting Johnston's specific name, as he considered it to be a sponge; and some years later (Hist. Brit. Zooph., 2nd ed., 1847, p. 202) he quotes Couch's description of *Z. couchii*, and has "the pleasure of naming this the only European Zoanthus after its discoverer." It is therefore clear that he did not regard his own form as a Zoanthean. We are thus obliged to adopt the specific name given to this species by Düben and Koren. Holdsworth, Gosse, and others have regarded this as a variety of *E. couchii:* we think that it will be admitted from our anatomical studies that this is not the case; neither can it be associated with *E. arenaceus*, D. Ch.

Owing to the kindness of Canon Norman we have been enabled to study some authentic Norwegian specimens of this species, and find them to be identical with the Shetland and Irish forms.

Dr. Gray had no hesitation in referring some specimens from the coast of Massachusetts, collected in forty-fathom water (Proc. Zool. Soc., 1867, p. 237), to

this species. Verrill, however, erected a new species for the forms dredged off the east coast of N. America. Thanks again to Canon Norman's courtesy we have examined some of Professor Verrill's specimens, and we must confess to not being able to distinguish them specifically from the European examples. It is difficult to understand why Professor Hertwig ignored these two specific names and adopted for his specimen (Challenger Sta., 49, off Nova Scotia, 85 faths.) the name of a form from the Pacific Ocean. Verrill (**1885**) says it (incrusting variety) ranges from "49–906 fathoms; abundant."

The synonymy has also been complicated on account of the occasional free habit. This variety was first named *Sidisia barleei* by Gray. Gosse, Holdsworth, and others have regarded it simply as a variety of the typically incrusting *Z. couchii.* Verrill, too, recognises a free and an incrusting variety of *E. americanus*, and also for his *E. abyssorum;* of this latter he says: "This species generally forms the carcinæcia of *Parapagurus pilosimanus*, but sometimes consists of two or three large obconic polyps arising from a grain of sand" (*l. c.* **1885**, p. 535).

Norman, however, in referring to this variety, says (**1868**, p. 319): "Taken abundantly in company with *Zoanthus incrustatus*, of which I was at one time inclined to consider it a variety; but more careful examination and dissection has convinced me that there are certain distinctions between the two, besides the fact of Sidisia being a free-living, unattached form. Whether these distinctions are specific or sexual, a careful examination of the living animal must hereafter determine." We have compared microscopically the two varieties, and find them to be essentially similar.

Incrusting Form.—Cœnenchyme incrusting gasteropod shells inhabited by hermit-crabs, the shells being rapidly absorbed and replaced by the cœnenchyme which thus forms the carcinæcium. In old specimens the polyps appear to be irregularly arranged; but on an examination of younger specimens, three series of polyps can be distinguished. In the youngest example we have seen (Pl. LVIII., fig. 14) there is only a single polyp, which is situated at the apex of a small gasteropod shell, the shell itself being entirely coated by the cœnenchyme. The second polyp arises at the oral axis, or hilum, of the shell (fig. 15). A third one usually makes its appearance above the mouth of the shell. We have seen several cases in which the apical polyp is in the act of fission (Pl. LVIII., fig. 12). These three polyps form the first series. The second series forms a marginal row which corresponds to the aboral varex of such a shell as Ranella. The third series forms an irregular row between the two former. In no specimen of the very large number we have examined is there a polyp on the under surface of the carcinæcium. The polyps bend slightly towards the oral or anterior aspect of the carcinæcium. In a contracted state the capitulum forms a

flattened disc-like termination to the polyp, on which indistinct radii, usually about 18 or 20 in number, can usually be discerned. The disc-like termination is sensibly of greater diameter than the column of the polyp.

Free Form.—The earliest stage we have seen consists of two polyps base to base. These may divide by fission more or less symmetrically (Pl. LVIII., figs. 5–11), or one polyp may divide repeatedly, and the other not at all (Pl. LVIII., fig. 2–4). The variations are so great that it would be impossible to attempt to describe them all; and we would here point out that the two species of Epizoanthus we have examined which have free forms (viz. *E. incrustatus*, *E. erdmanni*) vary in such a similar manner that the variations appear to have no taxonomic value; the same also holds good for *E. abyssorum*, Verr. We have seen specimens of similar varieties of other species which have not as yet been identified; one which comes from Naples will, we believe, be found to be a free variety of *E. arenaceus*. The size of the polyps and the character of the incrustations seem to be the only external features which distinguish the free forms of these species from each other, and these are obviously insufficient.

It is worthy of notice that the capitulum of the free varieties is usually less flattened than that of the incrusting forms.

The size which the polyps may attain apparently varies with the locality; for example, the largest of the Shetland specimens are 9 mm. in height, by 4·5 mm. in diameter; the largest colony from Balta measuring 30 × 20 mm.; that from Haaf being 35 × 20 mm. In the free variety the fully grown polyps average 6–7 mm. high, and 3–3·5 mm. across; the larger colonies being 22–23 mm. long by 8–11 mm. broad. From the S. W. of Ireland, the polyps range up to 7·5 mm. high by 3·5 in diameter, the carcinæcia being 24 × 15 mm. The W. of Ireland specimens from off Aran and from Donegal Bay run a good deal smaller: the polyps average 3–6 mm. in height and 1·5–3 mm. in diameter; most of the colonies are quite small, the largest being 22 × 13 mm. The nature of the incrustations also gives them a black-gray colour. The difference in size and colour between these and more normal specimens is so marked as to constitute a distinct variety.

Verrill's original description (**1866**, p. 34) of this species (his *Epizoanthus americanus*, n. sp.) is as follows:—" This species, which is parasitic on shells, has an incrusting base, smooth and uniform on the lower side of the shell, but giving rise to from fifteen to twenty polyps on the upper side, which diverge in all directions. Polyps variable in height and size, those of the upper central portion generally half an inch in height (13 mm.) and one-eighth (3·25 mm.) in diameter; while those around the margin of the base are not more than half so large, and much crowded. Base spreading over and completely investing dead shells of Natica, Buccinum, &c., both externally and internally. The substance of the

shell in every case has been entirely removed, but the form in all parts is perfectly preserved by the membranes of the polyps, while the cavity is inhabited by a species of hermit crab (*Eupagurus pubescens*). Column pillar-like, smallest in the middle, increasing gradually below, but enlarging rapidly at the summit. Walls thin, covered by a layer of closely adhering fine sand. When contracted, the summit is slightly concave; and in the medium-sized polyps has seventeen, in the largest twenty-four sulcations, radiating from the centre, which is seldom completely closed. Tentacles, forty-eight or more, short, conical.

The localities at which this species had been obtained up to that time are given by Verrill in **1882**, p. 316. The free or type-form (of *E. americanus*, Verr.) occurred at 28 stations, 28 to 487 fathoms, whereas the incrusting variety "(= *Zoanthus norvegicus*, Kor. & Dan.)" occurred at 11 stations, 69–160 fathoms. The former is by far the most abundant numerically. Later (**1885**), he gives the bathymetrical range of the free form as "26–547 fathoms; generally diffused and very abundant" (p. 534); and of the incrusting variety, "49–906 fathoms; abundant" (p. 535).

Smith and Harger (**1874**) report this species from off the coasts of New Jersey to the Gulf of St. Lawrence; the specimens with incrusted shells inhabited by *Eupagurus pubescens* came from 60–65 fathoms; while those from 430 fathoms were on stones and on hydroid stems. The figure, which is of a magnified polyp, is of no real value.

In Verrill's last Paper (**1885**, p. 60), he says it is mostly commensal with *Eupagurus politus*, Smith, and *E. kröyeri*, very common; those on grains of sand (free variety) were even more abundant. Some occurred incrusting sponges, shells, hydroids, tunicates, gorgonia, *Paramuricea grandis*, pebbles, &c. The original specimens off New Jersey, 30 fathoms, were commensal with *E. pubescens.* We think it possible that more than one species has been identified by our American colleague as *E. americanus.*

Body-wall (Pl. LIX., fig. 2).—The incrustations in this species are numerous, and consist for the most part of coarse grains of sand, so that it is difficult to make out the structure of the body-wall from our sections. The ectoderm is continuous, and is covered by a cuticle, to which diatoms and dark granules are attached. Nematocysts, containing similar granules, are usually abundant in the ectoderm. The incrustations are embedded in the mesoglœa throughout its entire thickness, often protruding into the cœlenteron. Single cells are occasionally found enclosed in the mesoglœa; and lacunæ are sometimes found near the union of the mesenteries with the body-wall; but the mesoglœa is for the most part devoid of cell enclosures. The usual endodermal muscular layer is present, being especially well-developed in the upper part of the column. The endoderm is formed by a thin layer of columnar cells of uniform height.

Sphincter muscle.—The mesoglœal sphincter muscle is short, and consists of well-defined cavities.

Disc and Tentacles.—The disc and tentacles present the usual structure. The muscular layers appear to be feebly developed.

Œsophagus.—The shape of the œsophagus in cross-section varies in our specimens. Sometimes it is almost circular (Pl. lx., fig. 1), the groove forming a very slight depression; in other specimens the groove is fairly-well marked. The ectoderm is almost smooth, being but very slightly folded.

Mesenteries.—The arrangement of the mesenteries is macrocnemic. The imperfect mesenteries are very slightly developed, extending into the cœlenteron but little beyond the endoderm. The ectoderm of the œsophagus is reflected, and forming a series of folds along each mesentery, is continued downwards in the usual manner to form the mesenterial filaments. The mesoglœa of the mesenteries is slightly developed. The muscle-fibres form simple layers, there being no mesoglœal plaitings. The endoderm of the mesenteries is thin, resembling that of the body-wall.

Gonads.—There were no gonads in the specimens examined by us.

Var. *barleei.*—The specimens we have cut of the free variety agree very closely in their anatomy with the above account; but the sphincter muscle appears to be longer and more powerful.

Epizoanthus paguriphilus.

(Pl. lviii., figs. 23–25; Pl. lix., fig. 6; Pl. lx., fig. 5.)

Epizoanthus paguriphilus:

Verrill, 1882, Am. Journ. Sci. (3), xxiii., pp. 137, 316; 1883, Bull. Mus. Comp. Zool., Cambridge, Mass., xi. (1883–85), p. 61, pl. viii., fig. 5; 1884, Am. Fish. Com. Rep. for 1882, p. 658; 1885, Am. Fish. Com. Rep. for 1883, p. 535, pl. viii., fig. 28. Bourne, 1890, Journ. Marine Biol. Assoc., i., p. 318.

Zoanthus (Corticanthus) paguriphilus:

Andres, 1884, Le Attinie, p. 326.

Form.—Colonies always forming carcinæcia; slightly incrusted; mesoglœa very thick; one polyp on ventral surface, the remainder forming a radiating single row, the "posterior polyp" of which is the smallest.

Colour.—Brownish in spirit specimens, but bluish-gray in colour where the thin incrustation is rubbed away.

Dimensions.—Average diameter of cœnenchyme, 55 mm.; average height of polyps, 20–25 mm.; average width of polyps, 12–16 mm.; average thickness of polyps, 8–10 mm.

Locality.—W. and S. W. Ireland:—50° 29′ 26″ N., 11° 4′ W., 400 faths., July 11, 1889 (G. C. Bourne): 500 faths., 54 miles off Achill Head, Co. Mayo, July 10, 1890 (A. C. H.), (Pl. LVIII., fig. 25). The specimens figured on Pl. LVIII., figs. 23, 24, are in the British Museum; they came from 71 miles W. by S. of the Fastnet, 315 faths., and possibly also from deeper water (*cf.* Ann. Mag. Nat. Hist. (6), IV., 1889, pp. 411, 430).

The geographical distribution of this species is North Atlantic, extending from the N. E. coast of America to N. W. Europe, in deep water.

This is the largest and most striking of the species of British Zoantheæ, and is quite a recent addition to our fauna.

The polyps are in two positions, one central and inferior, the remainder marginal, divergent, and uniserial. The cœnenchyme entirely surrounds the shell on which it grows, save for the orifice through which the commensal hermit-crab emerges. The orifice is ventrally situated, and is about 5 mm. distant from the anterior border of the carcinæcium, and is from about 15–20 mm. in diameter.

Immediately behind the orifice is a polyp, which in spirit-specimens does not rise above the general surface of the cœnenchyme, and is less than 10 mm. in diameter.

The marginal polyps are prominent, and elliptical in section. At the posterior end of the carcinæcium one polyp can readily be distinguished as being markedly smaller (15 mm. in height) than the other marginal polyps; this we term the "posterior polyp." There are in the three specimens which we have examined four well-grown polyps to the left of the posterior polyp, and four, five, and six, respectively, on the right side of the carcinæcium.

There is a space of 20 mm. between the right and left polyps on the anterior convex border of the carcinæcium. Under-surface of the carcinæcium flat; upper surface irregularly convex, with the greatest prominence towards the right.

A young specimen, which one of us dredged off the W. of Ireland, and which is drawn of the natural size in Pl. LVIII., fig. 25, shows that the order of the appearance of the polyps is probably as follows:—(1) the ventral polyp; (2) the posterior polyp; (3) the right and left anterior polyps; (4) the succeeding lateral polyps, of which the most posterior are the youngest. After four pairs of marginal polyps have appeared the further production of polyps appears to be confined to the right side.

This species is always commensal with *Eupagurus pilosimanus.*

Verrill first described this species in 1882 in the following terms:—"Polyps few and very large, stout, with broad, swollen bases, arising from a very thick, smooth, lubricous, gray or mud-coloured, translucent cœnenchyme, which at first invests small univalve shells, occupied by *Parapagurus pilosimanus*, but finally grows far larger than the shell, and eventually absorbs it. Disc broad, larger

than column; tentacles numerous, rather long, light orange. Breadth of colony, 2 to 3 inches; height of polyps in expansion, 1 inch or more; diameter, ·5 to ·7 of an inch" (p. 137). He further adds:—"Hitherto it has not been found elsewhere than upon the back of this particular species of crab, which, likewise, has not been found without its polyp. Of these associated creatures we took about 400 couples, at station 947, in 312 fathoms, at one haul. It had previously only been known by a few specimens taken by the Gloucester halibut fishermen, in deep water, off Nova Scotia, and by ourselves in 1880." On p. 316 of same journal (Am. Jour. Sci. (3), xxiii.) he adds:—"[Station 947, S. by W. $\frac{3}{4}$ W, 89 miles off Martha's Vineyard, sand, mud, Aug. 9, 1881; temperature 44° Fr. U. S. Fish. Com. Rep. for 1882–1884, p. 643]." "*Epizoanthus paguriphila*, Verrill, sp. nov., 252–458 faths."—and gives a list of the stations at which it was obtained.

In the Bulletin Mus. Comp. Zool. Cambridge, Mass., Verrill gives the colour as translucent bluish or purplish-gray, or grayish-brown. In fresh specimens the tentacles are pale-orange or salmon, with lighter tips, and polyps more or less of a salmon-colour. The diameter of ordinary specimens, 60–70 mm.; vertical thickness, 25–30 mm.; length of polyps, 15–20 mm.; diameter in middle, 10–12 mm.; and at base, 12–18 mm. Some specimens considerably larger than this were obtained. There are seven to twelve polyps.

Body-wall (Pl. lix, fig. 6).—The ectoderm is not continuous, but is penetrated by strands of mesoglœa, which unite (as in *Z. coppingeri* and other species of Zoanthus and of Isaurus, and also in *G. macmurrichi*, to form a peripheral layer of mesoglœa. This peripheral layer of mesoglœa is not distinguishable from the cuticle which covers the body. A more deeply stained outer layer may often be seen, but it appears to be simply due to the shrinking of the edge of mesoglœa under the action of heat. The columnar cells of the ectoderm are closely packed, and stain deeply. They often contain dark pigment granules. Nematocysts filled with similar pigment-granules are frequently found amongst them. The few foreign particles (chiefly foraminifera and grains of sand) which incrust this species are generally found partly embedded in the ectoderm and partly in the adjacent mesoglœa. The mesoglœa is remarkably thick, being relatively much thicker than in any other species of Zoanthean examined by us. In section the mesoglœa appears to enclose numerous "cell-islets." Some of these, however, are much elongated, and might possibly be regarded as forming parts of canals. We have not been able, however, to trace any distinct canals arising from either ectoderm or endoderm; and it seems more probable that all these cell enclosures are completely surrounded by mesoglœa. The usual spindle-shaped cells drawn out into long fibres can be discerned running through the mesoglœa. The endodermal muscular layer is not very well

developed; the fibres are supported on slight, rounded plaitings of mesoglœa. The endoderm consists of a single layer of columnar cells, the peripheral portion of the cells being of a deep brown colour owing to the presence of pigment-granules.

Sphincter muscle.—The single mesoglœal sphincter is not a very powerful one. No cavities are visible, the fibres being completely embedded in the substance of the mesoglœa.

Tentacles.—The ectoderm of the tentacles is thrown into transverse folds. Numerous pigment-granules are to be found amongst the usual small nematocysts, and the nuclei in the peripheral portion. The muscular layer is not well developed. The mesoglœa forms an extremely thin layer. The endoderm is also pigmented.

Disc.—The disc is very similar in structure to the tentacles.

Œsophagus.—The ectoderm of the œsophagus is thrown into numerous folds. There is a well-marked groove. The mesoglœa forms a thin layer, except in the region of the groove where it is somewhat thicker. It contains a few cell-islets.

Mesenteries.—The mesenteries have the usual macrocnemic arrangement. The reflected ectoderm of the œsophagus is attached to them in the lower part of the œsophageal region and lower down forms the filaments as in other Zoantheæ. The mesoglœa is well developed in the œsophageal region, and here, on one side of each mesentery, plaitings which support the longitudinal fibres can be distinctly seen. Plaitings on both sides of the mesentery nearer to the body-wall which support the parieto-basilar fibres are exceedingly slight. The mesoglœa is much thinner in the lower part of the body. The endoderm is very similar to that which lines the body-wall.

Gonads.—The sexes are distinct. Male gonads are present in our sections; they are very numerous, and closely packed together, almost entirely filling up the body-cavity below the œsophagus (Pl. LX., fig. 5).

Epizoanthus couchii (Johnston).

(Pl. LVIII., figs. 26–28; Pl. LIX., fig. 4; Pl. LX., fig. 3.)

Zoanthus couchii:

Johnston, 1838, in Couch, Cornish Fauna, III., p. 73, pl. XV., fig. 3 (not of Thompson, 1843, Br. Assoc. Rep., p. 284; nor of Thompson, 1844, Ann. Mag. Nat. Hist., XIII., p. 440; nor of Landsborough, 1845, *ibid.*, XV., p. 327; all of which are *Sarcodictyon catena*, cf. Johnston, 1847, *l. c.*, p. 180). Forbes, 1844, Ann. Mag. Nat. Hist., XIV., p. 415. Johnston, 1847, Brit. Zooph., ed. 2, p. 202, pl. XXV., fig. 9. Landsborough, 1852 (in part), Brit. Zooph., p. 225. Thompson, 1856, Nat. Hist. Ireland, IV., p. 462; Holdsworth, 1858 (in part), Proc. Zool. Soc., p. 557, pl. X., figs. 4–7. Wright and Greene, 1858, Brit. Assoc. Rep., p. 180. Gosse, 1860, var. *linearis*, Brit. Sea Anem., p. 297, pl. X., fig. 5. Hincks, 1861, Ann. Mag. Nat. Hist. (3), VIII., p. 363.

(*Dysidea* (?) *papillosa* :
Johnston, 1844, Hist. Brit. Sponges (in part), pp. 190, 251, pl. XVI., figs. 6, 7.

Carolia couchii :
Gray, 1867, Proc. Zool. Soc., p. 239.

Palythoa couchii :
Fischer, 1874, Nouv. Arch. Mus., Paris, pp. 235, 239; 1874, Comptes rendus, LXXIX., p. 1209 (trans. 1875, Ann. Mag. Nat. Hist. (4), XV., p. 374); 1875, Actes Soc. linn. Bordeaux, XXX., p. 8.

Polythoa arenacea :
(Not of D. Ch.) Andres, 1884, var. *couchii*, Le Attinie, p. 308; Pennington, 1885, var. *linearis*, Brit. Zooph. (in part), p. 182.

Palythoa arenacea :
(Not of D. Ch.) Carus, 1884, Prod. Faunæ Medit., p. 75.

Form.—Column cylindrical, rising to about three or four times its diameter. Margin cut into 12 or 14 (generally the latter number) large, fleshy, triangular teeth, which are connected by a thin web of transparent membrane. In a state of semicontraction these teeth form strongly marked, converging ridges on the flat summit of the column. Incrustations of fine sand. When the column is much distended, the grains of sand become considerably separated, and the visceral cavity can be seen through the transparent and smooth integuments. Disc, generally flat or slightly concave, but protusile in a conical form; radii distinct. Tentacles 28 (or 24), bicyclic, those of the inner row correspond to the marginal teeth; they are subequal, they taper gradually, are bluntly pointed, and about equal in length to the diameter of the column. Cœnenchyme, narrow, irregularly creeping, soft, invested with sand like the column.

Colour.—Column and cœnenchyme pale brown; disc pellucid, reddish-gray, dusted with excessively minute white specks; tentacles translucent, nearly colourless, opaque white tip; lip opaque white.

Dimensions.—"One-eighth of an inch [3 mm.] in diameter, and about thrice that height [9 mm.] in extension. In contraction the button is usually about a line [2 mm.] in height. Mr. Holdsworth has obtained specimens much larger than these."

Habitat.—"var. *linearis.*—The condition above described, in which the root-band creeps in a narrow ribbon over stones and shells. Cornwall and Devon."

The foregoing description is taken from Gosse, and refers to the specimens he had seen alive; perhaps he has incorporated older observations in it.

We have not been able to see any specimens of this species from the recorded localities, although we have made numerous efforts to do so. Our generous friend Canon Norman put some Zoantheæ from the Channel Islands at our disposal, which bear a very strong superficial resemblance to *E. couchii*, as defined

above; unfortunately they had been dried at some time or other, although they were in spirit when we had them, and though we made sections of them we could not make any satisfactory observations.

In order to facilitate the work of future observers we abstract all the additional information about this species, which is valuable from a descriptive point of view.

Johnston (**1847**) defines the genus and species as follows:—"Zoanthus: polypes distant, united by a creeping, root-like, fleshy band. *Z. couchii:* body cylindrical; tentacula in several circles." In quoting from Couch he adds the following details:—"It is a very small species . . . of a light sandy or opaque red colour, and its surface is minutely glandular [this is an error of observation, and probably refers to the grains of quartz]. In its contracted state it is sub-conoidal, resembling both in shape and size a split pea. When semi-expanded it elevates itself to about twice its former height, and becomes contracted about its middle into an hour-glass form. When fully expanded the tentacula become distended and elongated to about the length of the transverse diameter of the body; and they are generally darker at their extremities than towards the base."

Holdsworth (**1858**) obtained some specimens from 10–12 fathoms off Torbay. "One group of six polypes on the inside of a valve of *Cardium rusticum* is arranged in a linear series; . . . others are scattered over the surface of a flat stone, and have no perceptible connexion with one another, except in a few instances when two or three of them are united. . . . The body forms a cylinder from 2 to 4 lines [about 4·5–9 mm.], by about half that in breadth, and is clothed with a dense coating of fine sand, which at the upper extremity is divided into 14 deeply-cut, marginal teeth; these cover the top of the column when the animal is closed. The tentacula are moderate in length, slightly tapering, smooth. . . . They are arranged in two rows containing 14 each, of which the inner series are rather the longer, and are placed opposite the angular prolongations of the column, those of the outer row alternating with them. . . . The general colour of the disc and tentacula is a pale transparent brown, becoming opaque white around the mouth and at the tips of the arms, and all the intermediate parts are finely speckled with the same tint." The following year (**1859**) he obtained some much larger specimens from Torbay.

Hincks (**1861**) says, "Not uncommon: Salcombe Bay [Devonshire], on slate, stone, &c. (in about 12–15 fathoms)."

The following is a description of an Epizoanthus dredged by one of us in the S. W. of Ireland, and which we refer with some hesitation to this species. If *E. rubricornis* should prove to be a different species from *E. couchii*, our form will probably be found to be the same as the former, although the tentacles are of a different colour, and the habit of growth is different.

Form.—The column is elongated, tapering from above downwards; the body-wall is well incrusted, but when the sand is rubbed off, the body-wall is thin and translucent. The capitulum has about 14 ridges; these may be present or absent in preserved specimens; in the latter case their absence appears to be due to their being rubbed when in the dredge. Tentacles bicyclic, about 14 in number in each cyle, the inner being slightly the longer and more curved. Mouth linear, on a slight cone. Cœnenchyme, thin, either band-like, or forming small expansions.

Colour.—Sandy, sometimes dull, tawny-orange when alive; disc translucent buff, lips white, pale radii; tentacles translucent buff, opaque-white spot at tip.

Dimensions.—Usually about 10–14 mm. in height, and 2–3 mm. in diameter at the top of the contracted specimens, occasionally reaching a height of 18–20 mm., with a diameter of 4·5–5 mm.

Habitat.—S. W. Ireland; about 30 miles off Cape Clear (Pl. LVIII., figs. 27, 28), 80 fathoms; 40 fathoms off Glandore, Co. Cork; Berehaven, Bantry Bay, 10 fathoms (A. C. H.), (Pl. LVIII., fig. 26), [Proc. Roy. Irish Acad. (2), IV., Sci., 1886, in which Report Mr. S. O. Ridley identified this form as *Palythoa arenacea* (?), D. Ch., p. 617].

The Rev. Canon Norman has sent us specimens of an Epizoanthus from Birterbuy Bay, Co. Galway. They were unfortunately too badly preserved for us to be able to study them minutely, but at all events the sphincter muscle closely resembles that of our specimens from S. W. of Ireland, and externally they agreed fairly well with the English specimens of this species. Some very similar Channel Island specimens (identified as "*Z.*" *couchii*), which he gave us at the same time, probably belong to this species.

Fischer's (**1874**) description is as follows:—"The base of the colony is clothed with a layer of agglutinated sand, extending more or less; the polyps, irregularly disposed, have their column protected by a coating of sand; this is cylindrical and elongated when completely extended; colour cindery-gray; the superior border has 14 to 15 teeth. The tentacles, disposed in two rows, are short, whitish, and to the number of 28–30. The disc is whitish; the mouth small, transverse."

The specimens came from "Arcachon, from 20–45 brasses. The colonies were fixed on to the shell of *Chenopus pes-pelicani*, which gives lodging to a Sipunculus. Alder has identified it at Guernsey. M. Sauvage has obtained it at Boulogne on *Pecten maximus*, dredged in the channel" (p. 235). In his "bathymetrical distribution" he records this species on the oceanic coasts of France, from the Nullipore zone (28–72 metres), p. 239. The other Papers are merely abstracts.

To sum up the history of this species we may put the present state of our knowledge in this form. Johnston quotes Couch's description of the Cornish type specimens. Gosse, Holdsworth, and Hincks obtained Devonshire specimens which are probably the same as the former. Forbes identifies it as having been dredged

by Mac Andrew in Loch Fine, W. Scotland, in 1844. Thompson records it as having been dredged by himself and Hyndman in 1835 and 1846, 15–20 fathoms, from Strangford Lough (N.E. Ireland). Wright and Greene copy this. It may or may not be this species. We now describe specimens from S. W. Ireland which may possibly be this species: Fischer identifies it from the N. and W. coasts of France. Andres and Pennington merely quote Gosse.

Body-wall (Pl. LIX., fig. 4).—The body-wall is extremely thin in this species. The ectoderm, where present, is continuous, and is covered by a thin cuticle. It contains occasional nematocysts. Incrustations, which consist chiefly of grains of sand, are fairly numerous. Cell-enclosures are very rare. The endoderm is very thin, and of uniform thickness. The muscular layer is rather feebly developed.

Sphincter muscle.—The single mesoglœal sphincter is well developed, although it is not so powerful as in the free variety of *E. incrustatus.* It consists of elongated cavities which are well filled with muscle-fibres, the cavities forming for the most part a single row (Pl. LX., fig. 3).

Disc and Tentacles.—The structure of the disc and tentacles is for the most part as in other species of Zoantheæ; but oval nematocysts, similar to those which are found in the ectoderm of the body-wall and of the œsophagus, are present in the ectoderm of the tentacles of more than one of the specimens which we have cut. We have not, however, found them in all our specimens.

Œsophagus.—The ectoderm of the œsophagus is thrown into folds which appear to be deeper as a rule in the short than in the longer specimens. There is a well-marked groove. Nematocysts are generally to be found in this region; but in one or two specimens we have not been able to find them. In some cases they are very abundant. Sometimes they appear to contain black pigment-granules. In other cases they are quite clear, containing a distinct, coiled thread.

Mesenteries.—The mesenteries present the usual macrocnemic arrangement. The imperfect mesenteries are fairly well-developed. The longitudinal muscles are borne upon mesoglœal plaitings which are frequently well-marked, but in some of our specimens they are much slighter than in others. Nematocysts are very abundant in the ectoderm, which forms the mesenterial filaments in the usual manner.

Gonads.—We found no gonads in any of our specimens.

[**Epizoanthus arenaceus** (D. Ch.), (not British, Mediterranean). (*Polythoa* (str. s.) *arenacea.* Andres, 1884, p. 308. Type var. *Palythoa arenacea*, Carus, 1884. p. 75.)

(Pl. LIX., fig. 7; Pl. LX., fig. 4.)

Form.—Column cylindrical. Body-wall, thick and opaque, sometimes transversely wrinkled, about 15 capitular ridges and 30 tentacles; cœnenchyme incrusting, with a tendency to form linear bands.

Colour.—Dirty sand (in spirit).

Dimensions.—Height, 7–12 mm.; diam., 3·5–4·5 mm.

The above description is taken from specimens identified at the Naples Zoological Station. It will be seen that *E. arenaceus* differs from *E. couchii*, chiefly in the great thickness of its body-wall, which gives it a very characteristic appearance (Pl. LIX., fig. 7). Our specimens were not well preserved, and we have therefore some difficulty in determining satisfactorily anatomical characters. The mesoglœal sphincter muscle differs from that of *E. couchii* in the appearance of its cavities, the muscle-fibres being arranged in a single row round the mesoglœa, leaving an empty space in the centre of the cavity (Pl. LX., fig. 4). The thickness of the body-wall can be well seen in transverse sections. Nematocysts are present in the ectoderm of the œsophagus, and in the mesenterial filaments.]

Epizoanth macintoshi, n. sp.

(Pl. LVIII., fig. 29; Pl. LIX., fig. 1.)

Form.—Short, very stout, rigid column, incrusted with foraminifera which give it a very characteristic, white, granular appearance. Upper surface of contracted column with 18 radial ridges. Cœnenchyme apparently linear, of same nature as the wall of the column.

Colour.—Grayish white.

Dimensions.—(In spirit) one polyp, 7 mm. high by 6 mm. in diameter; the other, 5 mm. high by 4·5 mm. in diameter.

Locality.—Shetlands (1871).

A small colony of three specimens of this species was kindly handed over to us by Dr. W. C. M'Intosh, F.R.S., Professor of Zoology at St. Andrews. One of these we devoted to the microtome; the remaining specimens are in Prof. M'Intosh's collection. We are pleased to be able to associate such a well-marked species with the distinguished Scottish Zoologist who has placed his collection of Actiniæ at our disposal.

Body-wall (Pl. LIX., fig. 1).—The ectoderm is much broken, owing to the incrustations. Where present it is continuous, and is covered by a thin cuticle. Thread cells, containing a few, almost black, pigment-granules, are occasionally to be met with amongst the columnar cells of the ectoderm. The mesoglœa is thinner relatively to the diameter of the column than in most species of Zoantheæ. The incrustations consist almost exclusively of foraminifera, which are frequently so large that a single specimen extends right across the body-wall, and is partly embedded in the ectoderm and partly in the endoderm, as well as in the mesoglœa. There are hardly any cell-enclosures in the mesoglœa. Single cells only are occasionally to be seen enclosed. The endodermal muscular layer appears to be fairly well developed. The endoderm is formed by a thin layer of columnar cells of uniform height.

Sphincter muscle.—The single mesoglœal sphincter is thick, extending right across the wall of the capitulum. The cavities in the mesoglœa are large.

Disc and Tentacles.—The nuclei of the ectoderm are diffused, and do not form a central band. The muscular layers are well developed.

Œsophagus.—The ectoderm of the œsophagus appears to be quite smooth, not being thrown into folds. The groove is well marked, and there is a slight thickening of the mesoglœa in this region.

Mesenteries.—The arrangement of the mesenteries is macrocnemic. Owing to the presence of a parasitic crustacean in the single specimen we have cut it is difficult to determine the details regarding the mesenteries. The imperfect mesenteries extend but a short way into the body-cavity. The mesoglœa is well developed, and is thrown on one side of each mesentery into distinct plaitings, which support the longitudinal muscle-fibres. The parieto-basal muscles are less well developed, and appear to extend but a short way from the body-wall.

Gonads.—We found no gonads.

Parasitic Crustacean.—It is impossible to determine the nature of the crustacean infesting our specimen, or to say whether it is a fully developed or a larval form.

[**Epizoanthus norvegicus** (Kor. & Dan.). (Not British, Norway.)

(Pl. LIX., fig. 5.)

Form.—Rather more clavate than *E. macintoshi;* cœnenchyme forming expansions, in which the polyps, in the specimens we have examined, appear to have a tendency to form linear series.

Colour.—Sandy brown (in spirit).

Dimensions.—Height, 6–12 mm.; diam., about 6 mm.

We are again indebted to our friend Canon Norman for specimens (identified by Danielssen) of this species. Outwardly it differs from *E. macintoshi* in the rather more clavate form mentioned above, and in the darker and more brownish colour. Our specimens of either species are not sufficiently numerous to lay much stress on the difference in the cœnenchyme, which in many species varies much according to the nature of the body to which the polyps are attached. Anatomically the two species can be readily distinguished. The ectoderm of the body-wall in *E. norvegicus* is very thick, and is crowded with nematocysts (Pl. LIX., fig. 5). In *E. macintoshi* the ectoderm is very thin relatively to the diameter of the column, and contains very few nematocysts (Pl. LIX., fig. 1). The incrustations in *E. norvegicus* are various, consisting of spicules, grains of sand, and foraminifera. In *E. macintoshi* they consist almost exclusively of foraminifera. The endoderm also in *E. norvegicus* is much thicker than in *E. macintoshi*. The imperfect mesenteries in *E. norvegicus* are remarkably well developed. In *E. macintoshi* they are feebly developed, extending a very short way into the body-cavity.]

Epizoanthus wrightii, n. sp.

(Pl. LVIII., figs. 30–33; Pl. LIX., fig. 3; Pl. LX., fig. 2.)

Form.—Column somewhat thick-set, body-wall incrusted but not particularly rigid, 16 capitular ridges, mouth a narrow slit, with one œsophageal groove; tentacles 32 in number, bicyclic, transversely corrugated when not fully extended. Cœnenchyme broad, flat, irregular. Polyps arise from the cœnenchyme; craspeda ejected from the mouth when irritated.

Colour.—Dirty pellucid-white or orange-pink; in both the disc is speckled with opaque white; tentacles with an opaque white tip; craspeda, white or orange-pink, according to the colour of the polyp.

Dimensions.—Height, 13 mm.; diameter of column, 8·5 mm.; diameter of disc, 13 mm.; length of tentacles, 13 mm. Average height of expanded spirit specimens, 4 mm.; average diameter of column, 3 mm. In the contracted specimens the height and diameter are about equal, or the latter may even be the greater.

Habitat.—Dalkey Sound, Dublin Bay; between tides; spreading over incrustations on the granite rocks but never actually attached to the granite itself.

We are indebted to the brothers Dixon, for these specimens, and the above description is mainly taken from an account recently published by them ("Notes on the Marine Invertebrate Fauna of Dublin," Proc. Roy. Irish Acad., ser. III., vol. ii., p. 29, 1891). They very kindly placed all their specimens at our disposal. We have the pleasure of dedicating this species to our friend Dr. E. Perceval

Wright, who is so well-known as a student of the Actinozoa, and who is always so ready to help his scientific colleagues.

Body-wall (Pl. LIX., fig. 3).—The ectoderm, where present, is continuous. It consists of numerous granular and deeply staining columnar cells, with occasional nematocysts scattered amongst them. It is protected by a thick cuticle, which does not stain but is of a dark brown colour owing to the presence of dark brown granules and of various foreign bodies. Incrustations chiefly consisting of coarse grains of sand, with a few foraminifera, are embedded in the mesoglœa, which contains very few cell-islets or other enclosures. The endoderm is formed by a rather thin layer of ordinary columnar cells. The endodermal muscular layer appears to be but slightly developed.

Sphincter muscle.—The single mesoglœal sphincter consists of several rows of simple cavities at the distal end. Proximally it is reduced to a single row of very small cavities (Pl. LX., fig. 2).

Disc and Tentacles.—There is little worthy of note in the structure of the disc or tentacles. Both ectodermal and endodermal muscular layers are well developed.

Œsophagus.—The ectoderm of the œsophagus is thrown into well-marked folds; there is a distinct groove, but little if any thickening of the mesoglœa in this region.

Mesenteries.—The mesenteries have the usual macrocnemic arrangement. The imperfect mesenteries are distinct, although they extend but a short way into the body-cavity. The reflected ectoderm forms the mesenterial filaments in the usual way. The mesoglœa is not very well developed; both parieto-basilar and longitudinal muscles form almost simple layers. The endoderm is thinner than that of the body-wall, and contains in addition to the ordinary columnar cells, small oval cells which stain a very deep carmine.

Gonads.—No gonads were present in the specimens examined by us.

PROBABLY BELONGING TO THIS GENUS.

Zoanthus rubricornis, Holdsworth.

Zoanthus rubricornis:

Holdsworth, 1861, Proc. Zool. Soc.: and Ann. Mag. Nat. Hist. (3), VII., p. 484, woodcut.
Hincks, 1861, *loc. cit.* (3), VIII., p. 364.

Polythoa (*Endeithoa*) *rubricornis:*

Andres, 1884, Le Attinie, p. 316.

Form.—An unattached group of ten polyps, each gradually tapering from above downward, incrusted with sand; marginal serrations not nearly so conspicuous as in *E. couchii.*

Colour.—Tentacles a distinct red.

Dimensions.—Largest polyp, 25 mm. in height, and about 5–6 mm. diameter at the top when contracted. (Judging from the figure, 20 mm. is the average height, and 5 mm. the capitular diameter.)

Habitat.—Plymouth Sound.

This species has apparently never been met with since its discovery; and we are unable to do more than recast Holdsworth's description. We have no doubt that this species is an Epizoanthus; and it very closely resembles in outward appearance the specimens of *E. couchii*, which one of us has dredged off S. W. Ireland, the habit of growth being the most distinguishing feature, and upon this we do not place any reliance. Should this species be found to be distinct from *E. couchii* we expect that our Irish specimens would have to follow the former.

PARAZOANTHUS, n. g.

Macrocnemic Zoantheæ, with a diffuse endodermal sphincter muscle. The body-wall is incrusted. The ectoderm is continuous. Encircling sinus as well as ectodermal canals, lacunæ, and cell-islets in the mesoglœa. Diœcious. Polyps connected by thin cœnenchyme.

This is a very well marked genus anatomically; but it is often impossible to distinguish between certain species of this genus and those of Epizoanthus on external examination only.

We have taken for our type *P. axinellæ* (Schmidt), as this form is so readily obtainable, and, thanks to the Naples Zoological Station, is to be found in most museums. Another advantage is that it is one of the easiest of the incrusted Zoantheæ to study microscopically.

Erdmann was the first to separate the macrocnemic Zoantheæ, with a diffuse endodermal sphincter, from those with a mesoglœal muscle. He rightly retained the genus Epizoanthus for the latter, but wrongly referred the former to Palythoa, of which he also took *P. axinellæ* as the type. We have elsewhere (1891) entered into a detailed discussion of our reasons for restoring Palythoa to its type species *P. mammillosa* (E. & S.), and we consequently have to erect the new genus defined above.

BRITISH SPECIES OF THE GENUS PARAZOANTHUS.

P. anguicoma (Norman), 1868.

P. dixoni, n. sp.

SYNOPSIS OF BRITISH SPECIES OF PARAZOANTHUS.

(EXTERNAL CHARACTERS.)

Cœnenchyme thin, band-like, or inconsiderable; capitular ridges about 18, prominent, granulated, ...	*P. anguicoma.*
Cœnenchyme thick, soft, expanded; capitular ridges about 21; not so prominent as in former, ...	*P. dixoni.*

(ANATOMICAL CHARACTERS.)

Mesenteries project only a short distance from the body-wall into the cœlenteron; endoderm of moderate thickness, uniform; incrustations numerous, .	*P. anguicoma.*
Mesenteries project a considerable distance from the body-wall into the cœlenteron; endoderm forming very thick ridges between every two mesenteries; incrustations few, ...	*P. dixoni.*

The following species is inserted for comparison with the above:—

Cœnenchyme thin, band-like or irregular expansions; capitular ridges 13–15, not very prominent, ... Mesenteries much as in *P. anguicoma*; endoderm very thin and uniform; incrustations not very numerous, chiefly spicular, ...	*P. axinellæ* (Mediterranean).

Parazoanthus axinellæ (Schmidt).

Type species.—(Not British.)

(Pl. LIX., fig. 8; Pl. LX., figs. 6, 7.)

Palythoa axinellæ:

Schmidt, 1862, Spongien des Adriatischen Meeres, p. 61, pl. VI., figs. 2, 3. Gray, 1867, Proc. Zool. Soc., p. 238. Heller, 1868, Ber. k. zool., bot., Gesellsch., Wien, p. 21. Jourdan, 1880, Ann. des. Sci. Nat. (6), x., p. 43. Müller, 1883, Morphologie Palythoa u. Zoanthus, p. 8. Carus, 1884, Prod. Faunæ Medit., p. 76.

Zoanthus axinellæ:

Koch, 1880, Morph. Jahrb., VI., p. 359, pl. XVI., figs. 1–6.

Polythoa (str. s.) *axinellæ:*

Andres, 1884, Le Attinie, p. 311, pl. x., fig. 7.

Form.—Polyps obconical, coated with foreign particles; capitular ridges, 13–15, not very distinct. Tentacles, 26–30; pointed with a very slight

terminal swelling, perforated. Cœnenchyme band-like, linear, adhering to sponges; polyps usually in linear groups of three or four, sometimes solitary.

Colour.—Yellowish.

Dimensions.—Height, 7 mm.; diameter, 3 mm.; tentacles, 5–10 mm.

Habitat.—On various sponges, also on corallines and stones. Adriatic, Marseilles, Naples.

The foregoing description is compiled from the accounts given by Andres and Carus. In the specimens we have examined, as sent out by the Naples Zoological Station, we find that there is a considerable variation in the size of the polyps, some attaining a height of 13 mm., and the cœnenchyme forms an irregular expansion on which the polyps are very crowded. The following anatomical account is based upon these specimens. We leave it for others to determine whether more than one species is commonly identified as *P. axinellæ.* Koch's specimens appear to be the same as ours, so far as his description and figures go. The Adriatic specimens require re-investigation.

Body-wall (Pl. lix., fig. 8).—The body-wall is covered with a delicate cuticle, beneath which lies a rather thin layer of continuous ectoderm. Numerous oval nematocysts, which do not stain, are generally to be found among the granular and deeply staining columnar cells of the ectoderm. Incrustations, consisting for the most part of sponge spicules, are scattered, sometimes thickly, sometimes more sparingly, through the mesoglœa. Beneath these incrustations, separated from the endoderm by a thin layer of mesoglœa, lies an encircling sinus, containing deeply staining nuclei and cell contents, as well as numerous nematocysts similar to those which are found in the ectoderm. The sinus is frequently interrupted by bars of mesoglœa of variable thickness, so that in cross section it often appears to consist of a circular series of rather narrow lacunæ. Canals frequently branch off from the sinus, and in many cases their connexion with the ectoderm can be distinctly seen. Single isolated cells are occasionally found enclosed in the mesoglœa. The endoderm forms a very thin and almost uniform layer.

Sphincter muscle.—The sphincter muscle is, as described by Erdmann, diffuse and endodermal.

Disc and Tentacles.—There is nothing worthy of special note in the structure of the disc and tentacles.

Œsophagus.—The groove is well marked, and the mesoglœa is considerably thickened in this region (Pl. lx., fig. 6).

Mesenteries.—The arrangement of the mesenteries is macrocnemic. The imperfect mesenteries are well developed, often reaching nearly half way from the body-wall to the œsophagus. The longitudinal muscles are well developed in the upper part of the mesenteries, close to the disc, the fibres being supported in this

region by well developed mesoglœal plaitings. Lower down the plaitings disappear, the muscles forming an almost simple layer. Close to the disc a bundle of transverse fibres are seen on the opposite side of each mesentery to that which bears the longitudinal fibres. These seem to be the prolongations of the endodermal muscles of the disc and tentacles. The reflection of the ectoderm of the œsophagus, and its connexion with the filaments, can be well seen in this species (Pl. LX., fig. 6). The mesoglœa and the endoderm appear to be involved to some extent in the reflection also. The endoderm of the mesenteries forms, for the most part, a very thin layer, but it is much thickened in the region of the filaments (Pl. LX., fig. 7), the mesenteries in this region resembling those of *Z. macgillivrayi* (Pl. LXIV., fig. 8), but the thickening is not so marked as in that species, nor do we find here either zooxanthellæ or nematocysts.

Gonads.—In one of our specimens male gonads are present. They are surrounded by a thickened layer of endoderm (Pl. LX., fig. 7).

Parazoanthus anguicomus (Norm.).

(Pl. LVIII., figs. 34–36; Pl. LIX., figs. 11, 12.)

Zoanthus sulcatus ?:
Bowerbank, 1867, Proc. Zool. Soc., p. 351.

Zoanthus anguicoma:
Norman, 1868, "Shetland Report," Rep. Brit. Assoc., p. 319.

Polythoa (*Tæniothoa*) *anguicoma:*
Andres, 1884, Le Attinie, p. 317.

Palythoa, sp.:
Ridley, 1886, Proc. Roy. Irish Acad. (2), IV., Sci., p. 617.

Palythoa anguicoma:
Hertwig, 1888, Suppl. "Challenger" Rep., Actiniaria, p. 46, pl. I., fig. 7. Is probably not *P. anguicoma*, but an allied species, *P. hertwigi*, n. n.

Form.—Body rigid, rough; in some specimens the column has an almost warty appearance; capitular region swollen when contracted; radial ridges about 18 in number, prominent, rough. Tentacles in two cyles, of about 17 in each, very long and extensile, more than equal to diameter of disc when fully expanded; gradually attenuating to very slender points. Cœnenchyme incrusted, thin, either band-like, creeping on sponges and other objects, or forming broader expansions. The cœnenchyme is never well developed, and sometimes the polyps are isolated or in small groups. The smaller specimens, when contracted, have a button-like appearance.

Colour.—Pinkish-white (Norman); sand colour in preserved specimens.

Dimensions.—"Column, 3–5 times as high as broad" (Norman). Height of column, when fairly extended (in spirit), 13 mm.; diameter of withdrawn capitulum, 3–4 mm. In the "button" condition the height is much less, about 4–5 mm., or even less. Some West of Ireland specimens have, in spirits, a height of 15 mm., diameter of capitulum 5–6 mm., diameter of middle of column 3–4 mm.

Locality.—Shetlands, W. and S.W. Ireland. The exact localities for this species are as follows:—"Living on sponges, *Phakellia ventilabrum* and *P. robusta*, *Normania crassa*, *Oceanapia jeffreysii*, &c., in very deep water, 110–170 faths., 20–25 miles N.N.W. off Burrafirth Lighthouse" (A.M.N.), (Pl. LVIII., fig. 34); St. Magnus Bay, Shetland, 1867; "Porcupine, 1869, St. 8, 100–159 faths." [off Galway Bay, W. Ireland]. The foregoing are in Canon Norman's collection. 80 faths., 40 miles S.W. of Cape Clear, Co. Cork, 1885 (A.C.H.), (Pl. LVIII., fig. 36); 80 faths., off the Skelligs, Co. Kerry, July 13, 1886 (A.C.H.), (Pl. LVIII., fig. 35); 126 faths., off Achill, Co. Mayo, 1890 (A.C.H.).

This species is subject to considerable variation in general appearance, so much so that we at one time thought that the forms we had under review might belong to two species. This is the "squat button-like form" of Ridley (*l.c.*). There can be no doubt that this is the "*Zoanthus sulcatus* ?—dispersed in patches on the surface of *Desmacidon jeffreysii*, from Shetland," of Bowerbank. Hertwig (**1888**, Suppl. "Chall." Rept. Actiniaria, pp. 446–48) doubtfully refers a colony of "Palythoa" to this species from Inaccessible Island, Tristan d'Acunha (S. Atlantic), 60–90 faths. From Erdmann's anatomical investigations of these specimens it is certain that they belong to the genus Parazoanthus. The species is certainly very close to *P. anguicoma;* but we consider that the slight differences in the external characters, together with the "considerable hollow expansion" of the encircling sinus ("ring-canal") invariably opposite the insertion of the mesenteries, are sufficient to separate the two species, and for the latter we would propose the name of *Parazoanthus hertwigi.*

Body-wall (Pl. LIX., figs. 11, 12).—The ectoderm, where present, is continuous, and is covered by a thin cuticle. It forms a layer of variable thickness, and consists of columnar cells containing deeply staining granules, and of oval nematocysts which do not readily stain. Incrustations, consisting of sand spicules, foraminifera, &c., are fairly numerous, and are embedded both in the ectoderm and in the mesoglœa. There is a well-developed encircling sinus, which lies beneath the incrustations. It is of variable thickness, and is frequently crossed by strands of mesoglœa; but these strands are not at all so thick as those in *P. axinellæ*, and the sinus in consequence presents a much less broken appearance than in that species. Branching and anastomosing canals, very similar to those which we describe for *Z. coppingeri* (**1891**), connect the encircling sinus with the ectoderm. Nematocysts are frequently to be found in the encircling sinus.

Cell-islets and lucunæ are also often enclosed in the mesoglœa. The endoderm forms a thin layer of almost uniform thickness. The diffuse endodermal muscular layer is well developed.

Sphincter muscle.—The sphincter muscle is diffuse and endodermal, as in other species belonging to this genus. The mesoglœal plaitings are deep and well developed, but they branch very slightly.

Disc and Tentacles.—There is little worthy of special note in the structure of the disc and tentacles. The ectodermal muscles are exceedingly well developed.

Œsophagus.—The ectoderm of the œsophagus is generally thrown into folds, but these are in some cases very slight. There is generally a well-marked groove, the mesoglœa being here somewhat thickened. Occasionally cell-islets are to be found in this region.

Mesenteries.—The arrangement of the muscle is macrocnemic. The imperfect mesenteries generally extend well into the cœlenteron. The longitudinal muscles vary considerably in the degree to which they are developed, not only in individuals, but in different parts of the same individual. In some cases they form an almost simple layer, whilst in others they are supported on well-developed plaitings of the mesoglœa. The filaments are formed by the continuation of the ectoderm in the usual manner. Immediately below the œsophagus, the perfect mesenteries, bearing the filaments, extend but a short distance into the cœlenteron, leaving considerable empty space in the centre. Lower down they again increase in size, and near the base of the polyp they contain sinuses which appear to be of the same origin as the ectodermal enclosures of the body-wall.

Gonads.—There were no gonads in the specimens of this species which were examined by us.

Parazoanthus* dixoni, n. sp.

(Pl. LVIII., figs. 37, 38; Pl. LIX., figs. 9, 10; Pl. LX., figs. 8, 9.)

Form.—Body long, cylindrical, or quite short, smooth, or slightly roughened, very few incrustations. Polyps crowded, springing irregularly in all directions from an expanded, soft, thick cœnenchyme. Buds often arise from close to the bases of the older polyps. Scarcely any diminution in the length of the contracted polyps is noticeable as compared with the expanded specimens. The upper end of the contracted specimens is swollen, and has about 21 inconspicuous

* We name this species in honour of our friends the brothers G. Y. and A. F. Dixon, who have done much valuable work in connexion with the Irish Actiniæ.

radial ridges. Disc with distinct radii; mouth ellipsoidal, lips prominent. Tentacles in two cycles of about 21 in each; length about the diameter of the disc.

Colour.—Creamy white; polyps with a slight pinkish tinge.

Dimensions.—(In spirit). A. The larger specimens: height of column, 20 mm.; diameter, 4–5 mm.; diameter of disc and tentacles, 10 mm.; the cœnenchyme of one colony measured 60 mm. by 30 mm. (Pl. LVIII., fig. 37). B. Medium specimens: height of column, 16 mm.; diameter, 3 mm.; average diameter of disc and tentacles, 9 mm. C. Small variety: average height of column, 5 mm.; diameter, 4 mm. (Pl. LVIII., fig. 38).

Locality.—West of Ireland (5–8 miles W. of the Great Skellig, Co. Kerry, 70–80 faths., July 13, 1886. A. C. H.). This species was also obtained by the "Porcupine" in 1869. (No locality. Norman collection).

Body-wall (Pl. LIX., figs. 9, 10).—The ectoderm is continuous, and is covered by a thin cuticle. It forms a thick layer, consisting of very granular columnar cells, which stain deeply, and of numerous nematocysts which do not stain. The nematocysts in this species are scattered throughout the ectoderm in a fairly uniform manner. Incrustations consisting of spicules, grains of sand, and foraminifera may be found scattered at intervals through the mesoglœa, but in our specimens of the larger variety these are very rare. Beneath the incrustations lies a well-developed encircling sinus. It is frequently broken by strands of mesoglœa, and is connected with the peripheral ectoderm by numerous branching and anastomosing canals, very similar to those we find in *P. anguicoma.* The encircling sinus is connected with the endoderm by the fibrils or canalaculi of the mesoglœa, which are numerous and very distinct in our sections. The endoderm is not of uniform thickness as in *P. anguicoma*, but becomes very thick in the centre of each endocœle and ectocœle, thus forming a longitudinal ridge between every two mesenteries. The diffuse endodermal muscular layer is well developed.

Sphincter muscle (Pl. LX., fig. 8).—The diffuse endodermal sphincter is well developed, but very simple in character, the mesoglœa being raised into distinct but unbranched plaitings. In some sections some of these plaits appear to unite so as to enclose part of the muscle entirely in the mesoglœa, but we are uncertain whether this appearance is not due to the direction in which the sections are cut.

Disc and Tentacles.—There is little worthy of note in the structure of the disc and tentacles. The ectodermal muscular layer is well developed.

Œsophagus.—The ectoderm of the œsophagus is thrown into deep folds, into which the mesoglœa also enters. There is a deep, well-marked groove, and the mesoglœa is here very much thickened.

Mesenteries.—The arrangement of the mesenteries is macrocnemic. The imperfect mesenteries are well developed, and extend into the body-cavity nearly half-way between the body-wall and the œsophagus. The ectoderm of the

œsophagus is connected with the filaments in the usual manner. The mesoglœa of the mesenteries is well developed in all our specimens, and is thickened as well as raised into distinct plaitings on that side of each mesentery which bears the longitudinal muscle fibres (Pl. LX., fig. 9). The parieto-basal muscles are not so well developed as the longitudinal ones; and they extend along each side of the mesenteries, but a short way into the cœlenteron; there is therefore no difficulty in distinguishing between the two sets of muscles; and the pairing of the mesenteries can be very distinctly seen in this species. The endoderm of the mesenteries is thinner than that of the body-wall. The perfect mesenteries, from the termination of the œsophagus downward, extend far into the cœlenteron, which is, in consequence, almost filled up by the mesenteries and their filaments. Transverse sections of *P. dixoni*, taken just below the œsophagus, present in consequence a very different appearance from those of *P. anguicoma* taken from the same region. In our specimens of the small variety we find well-marked sinuses in the mesoglœa of the mesenteries, extending from the cœnenchyme a short distance upward into the cœlenteron, disappearing at about the lower termination of the mesenterial filaments. These sinuses are very similar in appearance to the ectodermal sinuses of *Z. coppingeri*, but we are unable to find in them any connexion with the ectodermal canals of the body-wall, whilst in several places they appear to be distinctly connected with the endoderm. We do not find these sinuses in the mesenteries of any of those specimens of the larger variety of *P. dixoni* which we have cut.

Gonads.—We have found no gonads in our specimens of this species.

OF UNCERTAIN POSITION.

Zoanthus sulcatus, Gosse.

Zoanthus sulcatus:

Gosse, 1860, Brit. Sea Anemones, p. 303, pl. IX., fig. 7; pl. XII., fig. 2. Hincks, 1861, Ann. Mag. Nat. Hist. (3), VIII., p. 364.

Gemmaria (?) *sulcata:*

Gray, 1867, Proc. Zool. Soc., p. 238.

Palythoa sulcata:

Fischer, 1874, Nouv. Arch. Mus. Paris, pp. 236, 239; 1874, Comptes rendus, LXXIX., p. 1207 (trans. Ann. Mag. Nat. Hist. (4), XV., p. 374); 1875, Actes Soc. linn. Bordeaux, XXX., p. 8; 1887, Arch. Zool. exp. gén. (2), V., pp. 435, 437. Jourdan, 1890, Bull. Soc. Zool., XV., p. 175.

Polythoa (*Tæniothoa*) *sulcata:*

Andres, 1884, Le Attinie, p. 317. Pennington, 1885, Brit. Zooph., p. 183.

Form.—Column generally cylindrical, but versatile; upper third of extended column free from sand, and indented with twenty-two longitudinal sulci; lower portion sparsely incrusted with very fine sand. Disc saucer-shaped. Tentacles,

42, in two rows, the inner row corresponding in position to the marginal teeth, the outer intermediate; sub-equal, conical, pointed, usually radiating horizontally. Cœnenchyme band-like, often bearing three polyps abreast, loosely invested with coarse sand.

Colour.—Column dull uniform olive, each intersulcus having a blackish spot near its summit; each tooth is silvery white. Disc olive-yellow; tentacles colourless, transparent, with yellow-brown pigment granules.

Dimensions.—Column about 3 mm. high, and about 2 mm. wide.

Locality.—Torbay, on rock, between tidemarks.

Hincks (*l. c.*, p. 364) says:—"Mr. Gosse mentions a single colony of this pretty but very minute species as having occurred to him at Broadsands, near Brickham, on sandstone rock. On the opposite side of Torbay, however, and very close to Torquay, I have found it abundantly in the small basins hollowed out in the limestone. The Zoanthus forms little colonies on the floor of these miniature pools; but they may readily be passed over as tufts of some minute weed." Mr. G. Y. Dixon informs us that he has carefully hunted over the rock where Gosse obtained his original specimens, without being able to re-discover this species.

Fischer (**1874**, p. 236) describes this species as follows:—"Column covered in its superior half with very fine and agglutinated sand, uniformly brownish or olive, with 22 rays or ridges, on which one sees grains of sand arranged in vertical lines. The superior border of the column is indicated by a dentate border; the teeth are 11 in number, and their colour is white. The disc of the same colour as the column appears rayed. The tentacles to the number of 22 are arranged in two rows; the 11 tentacles of the inner row are longer than the marginal by a third or a fourth. They are conical, transparent, ornamented with some brown spots; their extremities have an opaque white colour. The yellow mouth is not prominent."

"I have found this species at the landing place of Arcachon, at the limit of low tide; it forms very numerous colonies, which have an appearance of the perforating sponges (Cliona), but their colour is more pronounced. The colony is fixed upon an expansion thickened by sand and other adherent matter. This is perforated by circular holes for the emission of the Zoantheæ, which sink in and disappear when they are disturbed. M. Lafont has met with this species at Guéthary, on rocks.

"The figure given by Mr. Gosse is very bad. . . . The small size, the colour, the habitat of this species, readily distinguish it from the preceding [*E. couchii*]. When it is extended it measures 4 mm. in diameter." It occurs between tides (littoral zone), p. 239. The other Papers are merely abstracts.

Later (**1887**), Fischer gives the following French localities:—"Le Croisic, Piriac (Région armoricaine); Arcachon, Guéthary, (Région aquitanique); Zone littorale," p. 435.

Jourdan has recently (**1890**, p. 175) identified a form dredged by the Prince of Monaco (? either from the Bay of Biscay or off the Azores) as "*Palythoa sulcata* Gosse."

Zoanthus alderi, Gosse.

Zoanthus alderi:

Gosse, 1860, Brit. Sea Anemones, p. 305, pl. IX., fig. 8; pl. XII., fig. 5. Gray, 1867, Proc. Zool. Soc., p. 234. Pennington, 1885, Brit. Zooph., p. 183. Alder, Trans. Tyneside Nat. Field Club, v.

Zoanthus (*Rhyzanthus*) *alderi:*

Andres, 1884, Le Attinie, p. 328.

Form.—"Polyp inversely conical, the summit being two or more times as broad as the base; summit (in the button state) swelling, flat, depressed in the centre, with many (about twenty?) radiating striæ, indicating the marginal teeth. Surface smooth, without any investment of sand, but marked throughout with close-set, transverse, or annular wrinkles. Cœnenchyme narrow, smooth, irregularly branching, free from sand."

Colour.—Opaque, milk-white.

Dimensions.—Height of column about two lines (4 mm.); greatest diameter about half a line (1 mm.).

Habitat.—Northumberland; under-surface of a stone, at extreme low water, near the "Bear's Rock," Cullercoats (Alder).

This species has not been met with since its first discovery by J. Alder in 1857. Gosse says: "There were about a dozen polyps in the colony, all of the same size, which seems to be good evidence that they had attained adult dimensions." Alder adds that he has "searched for it several times without success." We cannot help regarding this as an immature form.

No representative of the genus Zoantha, as determined by anatomical investigation, is known to occur in the extra-tropical portion of the North Atlantic.

Until the anatomy of "*Z. rubricornis*," "*Z. sulcatus*," and "*Z. alderi*" is investigated it will be impossible to tell the genus, let alone the species. The same criticism applies to the identification of nearly all the Zoantheæ.

BIBLIOGRAPHY OF THE ZOANTHEÆ.

1767. ELLIS, J.:

An account of the *Actinia sociata*, &c. (Phil. Trans. Roy. Soc., LVII., pt. i. (1768), p. 428, pl. xix.)

1786. ELLIS, J., AND SOLANDER, D.:

The Natural History of many curious and uncommon Zoophytes. London, pls.

1798. CUVIER, G. C. L. D.:

Tableau élémentaire de l' Histoire naturelle des Animaux. (Ann. 6, Journ. de Phys., XLVI., pp. 370–384.)

1801. LAMARCK, J. B.:

Système des Animaux sans Vertèbres. Paris.

1802. BOSC, L.:

Histoire naturelle des Vers. Suites à Buffon. Castel, Paris.

1816. LAMOUROUX, J. V. F.:

Histoire générale des Polypiers coralligènes flexibles. Caen.

1817. CUVIER, G. C. L. D.:

Règne animale, IV.

1817. LESUEUR, C. A.:

Observations on several species of the Genus Actinia. Illustrated by figures. (Journ. Acad. Nat. Sci. Philadelphia, I., pp. 149, 169, pls. vii., viii.)

1821. LAMOUROUX, J. V. F.:

Exposition méthodique des genres de l'ordre des polypiers avec leur description et celle des principales espèces figurées dans 84 planches; les 63 premières appartenant a' l'histoire naturelle des Zoophytes d' Ellis et Solander. Paris.

1828. GRAY, J. E.:

Spicilegia Zoologica, pls.

1830. LESSON, R. P.:

Zoologie. Voyage autour du monde sur la corvette de S. M. la Coquille, pendant les années 1822–1825, par L. J. Duperrey. Paris, 1828, pls.

1832. DELLE CHIAJE, S.:

Istituzioni d' Anatomia comparata. Napoli, pls., (edition 2, 1836).

1833. QUOY ET GAIMARD:

Zoologie du Voyage de la corvette l'Astrolabe, pendant les années 1826–1829, by G. Dumont d'Urville. Paris, 1830, pls.

1834. EHRENBERG, C. G.:

Beiträge zur physiologischen Kenntniss der Korallenthiere im Allgemeinen und besonders des Rothen Meeres nebst einem Versuche zur physiologischen Systematik derselben. (Abhandl. d. König. Akad. d. Wissensch., Berlin, 1832, p. 225.) [Published in 1834, and also as a separate volume, Die Korallthiere des Rothen Meeres.]

1834. JOHNSTON, G.:

Illustrations in British Zoology. *Spongia suberia.* (Loudon's Mag. Nat. Hist., VII., p. 491, fig. 60).

1834. BLAINVILLE, H. M. DE:

Manuel d' Actinologie ou de Zoophytologie, with Atlas. Paris.

1836. LAMARCK, J. B.:

Histoire des Animaux sans Vertèbres. [Deshayes and Milne Edwards' revised and augmented edition.]

1838. COUCH, J.:

A Cornish Fauna, being a Compendium of the Natural History of the County. London.

1842. JOHNSTON, G.:

History of British Sponges and Lithophytes, pls. and woodcuts. Edinburgh.

1843. THOMPSON, W.:

Report on the Fauna of Ireland, div. Invertebrata. (Brit. Assoc. Rep., p. 245.)

1844. THOMPSON, W.:

Additions to the Fauna of Ireland. (Ann. Mag. Nat. Hist., XIII., p. 430.)

1844. FORBES, E.:

Notice of some additions to the British Fauna discovered by Robert Mac Andrew, Esq., during the year 1844. (Ann. Mag. Nat. Hist., XIV., p. 415.)

1845. LANDSBOROUGH, D.:

Notice of some Rarities found on the West Coast of Scotland. (Ann. Mag. Nat. Hist. (1), XV., p. 327.)

1846. DANA, J. D.:

Report on Zoophytes, U. S. Explor. Exped., 1838–1842, with Atlas.

1847. JOHNSTON, G.:

A History of British Zoophytes, vol. i., vol. ii, pls., 2nd edit. [The one which is always used.]

1847. DÜBEN, M. W., AND KOREN, J.:

Om. nogle norske Actinier. (Forhandl. Skan. Naturf. Möde, p. 266.)

1848. DÜBEN, M. W., AND KOREN, J.:

Ueber einige norwegische Actinien. Isis, p. 536.

1851. SARS, M.:

Beretning om en i Sommeren 1849, foretagen zoologisk Reise i Lofoten og Finmarken. (Nyt Mag. Naturvid., VI. (2), p. 122.)

1851. LE CONTE, J. L.:

Zoological Notes. New species of . . . . Zoantha. (Proc. Acad. Nat. Sci. Philadelphia, v., p. 320.)

1856. THOMPSON, W.:

The Natural History of Ireland. (London, 1849–1856, vol. iv., 1856.)

1856. STEENSTRUP, J. J. S.:

Kongelige Danske Videnskab. Selskabs. Forhandl.

1857. MILNE-EDWARDS, H.:

Histoire naturelle des Coralliaires, ou Polypes proprement dits, I., with atlas. Paris.

1858. GRAY, J. E.:

On the *Dysidea papillosa* of Dr. Johnston. (Proc. Zool. Soc., 1858, p. 531, pl. X., fig. 8, of separate vol., "Radiata"). [*Sidisia barleei*, g. and sp. nn.]

1858. HOLDSWORTH, E. W. H.:

On *Zoanthus couchii*, Johnston. (Proc. Zool. Soc., 1858, p. 557, pl. X., figs. 3–7.)

1858. WRIGHT, E. P., AND GREENE, J. R.:

Report on the Marine Fauna of the South and West Coasts of Ireland. (Brit. Assoc. Rep., p. 176.)

1858. GRAY, J. E.:

Note on *Dysidea papillosa*, Johnston. (Ann. Mag. Nat. Hist. (3), II., p. 489.)

1859. DANIELSSEN, D. C.:

Beretning om en zoologisk Reise foretagen i Sommeren 1857. (Nyt Mag. Naturvid., XI (1861), p. 1.)

1859. HOLDSWORTH, E. W. H.:

On *Zoanthus couchii*, Johnston. (Ann. Mag. Nat. Hist. (3), IV., p. 152.)

1860. SARS, M.:

Oplysninger om nogle Cœlenterater fra Norges Kyster. (Forhandl. Skand. Naturf. Möde. Kjöbenhavn, VIII., p. 690.)

Om nogle nye eller lidet bekjendte norske Cœlenterater. (Forhandl. Vidensk. Selsk. Christ.)

1860. GOSSE, P. H.:

Actinologia Britannica: A History of the British Sea Anemones and Corals. London. [Part XI., pp. 321–352, which contains the Zoantheæ, was published in Nov., 1859.]

1860. DUCHASSAING, P., ET MICHELOTTI, J.:

Mémoire sur les Coralliaires des Antilles. (Mem. Reale Accad. Sci., Turin (2), XIX. (1861), p. 279, pls.)

1861. HOLDSWORTH, E. W. H.:

On an Undescribed species of British Zoanthus. (Proc. Zool. Soc., 1861, p. 99; also in Ann. Mag. Nat. Hist. (3), VII., p. 484, fig.) [*Z. rubricornis*, n. sp.]

1861. HINCKS, T.:

Catalogue of the Zoophytes of South Devon and South Cornwall. (Ann. Mag. Nat. Hist. (3) VIII., p. 364.)

1862. ALDER, J.:

Supplement to a Catalogue of the Zoophytes of Northumberland and Durham. Trans. Tyneside Nat. Field Club, v., pt. iii.) [Vol. v. runs from 1861–1863.]

1862. SCHMIDT, O.:

Spongien des Adriatischen Meeres. Leipzig, pls.

1864. VERRILL, A. E.:

Revision of the Polypi of the Eastern Coast of the United States. (Mem. Boston Soc. Nat. Hist., I. (read 1862, published 1864), p. 1, pls.)

1866. VERRILL, A. E.:

On the Polyps and Echinoderms of New England. (Proc. Boston Soc. Nat. Hist., X., p. 333.)

1866. DUCHASSAING, P., ET MICHELOTTI, J.:

Supplément au Mémoire sur les Coralliaires des Antilles. (Mem. Reale Accad. Sci., Turin (2) XXIII., p. 97, pls.)

1867. BOWERBANK, J. S.:

Additional Observations on *Hyalonema mirabile*. (Proc. Zool. Soc., p. 350.)

1867. Gray, J. E.:

Notes on the Zoanthinæ, with Descriptions of some New Genera. (Proc. Zool. Soc., 1867, p. 233, woodcut.) [Brit. sp. referred to—*Zoanthus alderi; Sidisia barleei;* Epizoanthus, n. g.; *E. papillosus; Gemmaria* (?) *sulcata;* Carolia, n. g.; *C. couchii.*]

1868. Heller, C.:

Die Zoophyten und Echinodermen des Adriatischen Meeres. (Ber. k. zool. bot. Gesellsch., Wien.)

1868. Norman, A. M.:

Last Report on Dredging among the Shetland Isles. (Brit. Assoc. Rep., p. 232.)

1869. Verrill, A. E.:

Notes on Radiata. Review of the Corals and Polyps of the West Coast of America. (Trans. Connect. Acad., i., 1867–1871, p. 377 (p. 495, Mar., 1869).)

1872. Dana, J. D.:

Corals and Coral Islands.

1873. Verrill, A. E.:

Report upon the Invertebrate Animals of Vineyard Sound and the Adjacent Waters, with an Account of the Physical Characters of the Region. iv., 5, Fauna of the Muddy Bottoms off the open Coast. (Report of the United States Commissioner of Fish and Fisheries, 1873, pp. 295–747, pls. i. to xxxviii.)

1874. Fischer, P.:

Sur les Actinies des côtes océaniques de France. (Comptes rendus, lxxxix., p. 1207; translated in Ann. Mag. Nat. Hist. (4), xv., 1875, p. 373.)

1874. Fischer, P.:

Recherches sur les Actinies des côtes océaniques de France. (Nouv. Arch. du Muséum, Paris, x., p. 193.) [The title page of the vol. gives 1874, but Dr. Fischer (1887) and other authors give the date as 1875.]

1874. Smith, S. J., and Harger, O.:

Report on the Dredgings in the Region of St. George's Banks in 1872. (Trans. Connect. Acad., iii., p. 1, pls.)

1875. Martens, E. von:

Ueber Palythoa. (Sitzungesber. Gesell. Naturf. Freunde. Berlin, p. 21.)

1875. Fischer, P.:

Anthozoaires du département de la Gironde et des côtes du sud-ouest de la France. (Actes Soc. linn. Bordeaux, xxx., p. 183.)

1877. Andres, A.:

On a New Genus and Species of Zoanthina malacodermata [*Panceria spongiosa*, sp. n.] (Quart. Journ. Micr. Sci. (N. S.), 1877, p. 221 pl. xvi.)

1877. KLUNZINGER, C. R.:

Die Korallthiere des Rothen Meeres, I. Alcyonarien und Malacodermen. Berlin.

1878. STUDER, T.:

Zweite abtheilung der Anthozoa polyactinia, welche während der Reise S. M. S. Corvette Gazelle um die Erde gesammelt werden. (Monatsber. Königl. preuss. Akad. Wissensch. Berlin, p. 524, pl.)

1880. KOCH, G. VON:

Notizen über Korallen. (Morph. Jahrb., VI., p. 355, pl. XVI.)

1880. JOURDAN, E.:

Recherches zoologiques et histologiques sur les Zoanthaires du Golfe de Marseille. (Ann. des Sci. Nat. (6), X., p. 1.)

1882: VERRILL, A. E.:

Notice of the remarkable Marine Fauna occupying the outer banks of the Southern Coast of New England, No. 3. (Am. Journ. Sci. (3), XXIII., p. 135; *ibid.*, No. 5, p. 309.)

1882. HERTWIG, R.:

Report on the Actiniaria dredged by H. M. S. "Challenger" during the years 1873-1876. (The Zoology of the Voyage of H. M. S. "Challenger," pt. XV., 1882, pls. Supplement, 1888, pls.)

1882. MARION, A. F.:

Actiniaires atlantiques des dragages de l'aviso le Travailleur. (Compt. rend., XCIV., p. 458; translated in Ann. Mag. Nat. Hist. (5), IX., p. 334.)

1883. VERRILL, A. E.:

Report on Anthozoa and on some additional Species dredged by the "Blake," in 1877–1879, and by U. S. Fish Commission Steamer "Fish Hawk" in 1880–1882. (Bull. Mus. Comp. Zool. Cambridge, Mass., XI., 1883-1885.)

1883. MÜLLER, G.:

Zur Morphologie der Scheidewände bei einigen Palythoa und Zoanthus. Marburg. [Dissertation for Doctor's degree privately printed.]

1884. CARUS, J. V.:

Prodromus Faunæ Mediterraneæ. Stuttgart.

1884. ANDRES, A.:

Le Attinie. (Fauna u. Flora d. Golfes v. Neapel, IX. Leipzig.) [Published in the Atti. R. Accad. dei Lincei, Rome (3A), XIV., 1883.]

1884. VERRILL, A. E.:

Notice of the remarkable Marine Fauna occupying the outer banks off the Southern Coast of New England, and of some additions to the Fauna of Vineyard Sound. (Am. Fish. Com. Rep. for 1882, p. 641.) [Partial reprint of Verrill, 1882.]

1885. VERRILL, A. E.:

Results of the Explorations made by the steamer "Albatross" off the Northern Coast of the United States in 1883. (U. S. Fish. Commission Report for 1883, p. 503, pls.)

1885. PENNINGTON, A. S.:

British Zoophytes: an Introduction to the Hydroida, Actinozoa, and Polyzoa found in Great Britain, Ireland, and the Channel Islands; with plates. London.

1885. ERDMANN, A.:

Ueber einige neue Zoantheen. Ein Beitrag zur anatomischen und systematischen Kenntniss der Actinien. (Jenaische Zeitschr. Naturwiss., XIX., p. 430, pls.)

1886. KOCH, W.:

Neue Anthozoen aus dem Golf von Guinea. Marburg, 36 pp., 5 pls.

1886. RIDLEY, S. O.:

Zoanthidæ—First Report on the Marine Fauna of the South-West of Ireland. (Proc. Roy. Irish Acad. (2), IV., Sci., p. 599.)

1887. FISCHER, P.:

Contribution à l'Actinologie française. (Arch. Zool. exp. et gén. (2), V., p. 381.)

1888. HERTWIG, R.:

Supplementary Report. (See 1882.)

1889. HADDON, A. C.:

A Revision of the British Actiniæ, pt. I. (Trans. Roy. Dubl. Soc. (2), IV., p. 297, pls.)

1889. FISCHER, P.:

Nouvelle contribution à l'Actinologie française: 1e partie, Actinies d'Arcachon; 2e partie, Actinies de Guéthray. (Actes. Soc. linn. Bordeaux, XLIII., p. 252.)

1889. McMURRICH, J. PLAYFAIR:

A Contribution to the Actinology of the Bermudas. (Proc. Acad. Nat. Sci., Philadelphia, p. 102, pls. VI., VII.)

1889 A. McMURRICH, J. PLAYFAIR:

The Actiniaria of the Bahama Islands, W. I. (Journal of Morphology, III., p. 1, pls. I.–IV.) [The latter Paper was written before the former, though it was published slightly subsequently to it.]

1890. DANIELSSEN, D. C.:

Actinidæ. (The Norwegian North Atlantic Expedition, 1876–1878. Zoology. pls.)

1890. BOURNE, G. C.:

Report of a Trawling Cruise in H. M. S. "Research" off the South-West of Ireland. (Journal Marine Biological Association (Plymouth), I., p. 306.)

1890. JOURDAN, E.:

Note préliminaire sur les Zoanthaires provenant des Campagnes du Yacht l' Hirondelle, 1886–1888. (Bull. Soc. Zool. Paris, xv. p. 174.)

1890. BENEDEN, E. VAN:

Les Anthozoaires pélagiques recueillis par M. le Prof. Hensen dans son Expéd. du Plankton. 1. Une Larve voisine de la Larve de Semper. (Bull. Acad. roy. Belgique (3), xx., p. 55, pl.)

1891. McMURRICH, J. PLAYFAIR:

Contributions on the Morphology of the Actinozoa. III. The Phylogeny of the Actinozoa. (Journal of Morphology, v., pp. 125–164, pl. IX.)

1891. HADDON, A. C., AND SHACKLETON, A. M.:

Actiniæ.—I. Zoantheæ. Reports on the Zoological Collections made in Torres Straits by A. C. Haddon, 1888–1889. (Trans. Roy. Dubl. Soc., vol. IV., ser. ii., pt. XII.)

INDEX OF GENERA AND SPECIES.

EXPLANATION OF PLATE LVIII.

PLATE LVIII.

Fig.

1–22. *Epizoanthus incrustatus* (Düb. & Kor.), (p. 636).

1–11. Free variety from Shetland; Mus. Normani—1, simple form, with two polyps; 2–4, 5–8, 9–11, three varietal series.

12–13. Typical incrusting forms from Shetland; Mus. Normani.

14–21. Incrusting forms from Galway Bay. These are rather smaller and darker than the more usual forms. This series, starting from a single polyp, illustrates the manner in which new polyps arise.

22. Antero-posterior section of a carcinæcium, to show the position of the polyps and the absence of a ventral polyp.

All the above are drawn from spirit specimens, and are natural size.

23–25. *Epizoanthus paguriphilus*, Verr. (p. 641).

23–24. Upper and under surface of two different specimens from off S.-W. Ireland; half natural size.

25. Young specimen from W. of Ireland; natural size; *p.p.* posterior polyp.

26–28. *Epizoanthus couchii* (Johnst.), (p. 644).

26. Living specimen from Berehaven; drawn by A. C. H.

27–28. Spirit specimens from S.-W. Ireland; all natural size.

29. *Epizoanthus macintoshi*, n. sp. (p. 649).

Spirit specimen from Shetland; natural size.

30–33. *Epizoanthus wrightii*, n. sp. (p. 651).

30–32. Living specimens from Dublin Bay; drawn by Mr. G. Y. Dixon; not to scale. 32 showing larvæ swimming inside the tentacles.

33. Spirit specimen; natural size.

34–36. *Parazoanthus anguicoma* (Norm.), (p. 656).

34. Some of the original type specimens, consisting of one isolated example, and a group of four polyps on a sponge, from Shetland (the specimen has unfortunately dried up); Mus. Normani.

35. Ordinary forms from S.-W. Ireland, on the tube of a Serpula.

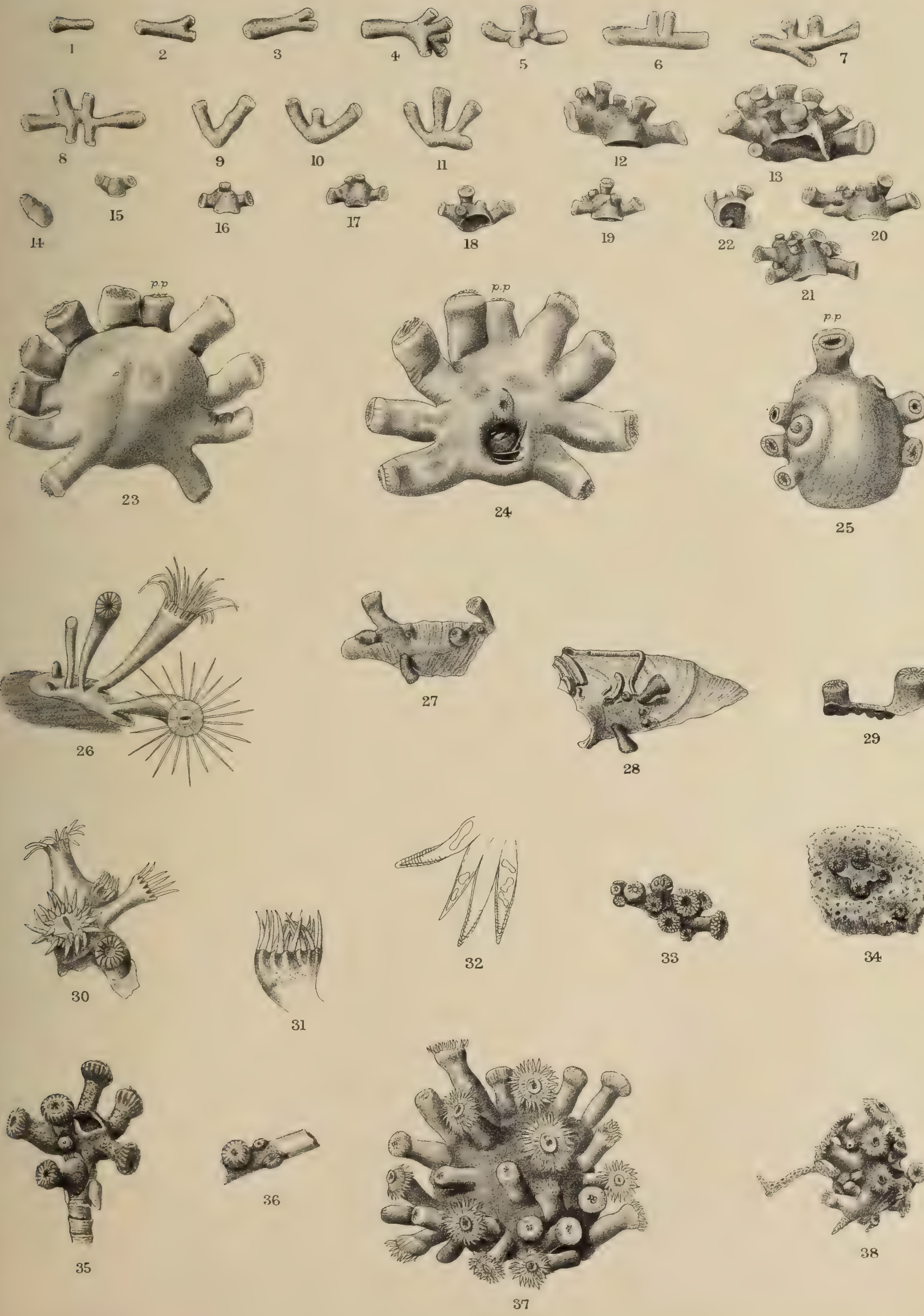
36. Button-like variety, on the tube of a Hyalonœcia; both natural size, from spirit specimens.

37–38. *Parazoanthus dixoni*, n. sp. (p. 658).

37. Group of living specimens from S.-W. Ireland; tall variety; drawn by A. C. H.

38. Short variety; spirit specimens all natural size.

[All the above specimens are in the British Museum, excepting Nos. 1–13 and 34. No. 29 was presented by Prof. W. C. M'Intosh, and No. 33 by Mr. G. Y. Dixon.]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EXPLANATION OF PLATE LIX.

PLATE LIX.

LETTERING ADOPTED IN THE FIGURES.

cu., ...	cuticle.	*f.*, ...	fibrilla.
ect., ...	ectoderm.	*incr.*, ...	incrustation.
ect. can., . . .	ectodermal canal.	*m.*, ...	mesoglœa.
enc. sin., . . .	encircling sinus.	*mes.*, ...	mesentery.
end., ...	endoderm.	*nem.*, ...	nematocyst.
end. can., . .	endodermal canal.	*p. b. m.*, . . .	parietò-basilar muscle.

Fig.

1. *Epizoanthus macintoshi*, n. sp. (p. 649). Transverse section through the body-wall, $\frac{2}{B}$.*

2. *Epizoanthus incrustatus* (Düb. & Kor.), (p. 636). Transverse section through the body-wall, $\frac{2}{B}$.

3. *Epizoanthus wrightii*, n. sp. (p. 651). Transverse section through the body-wall, $\frac{2}{B}$.

4. *Epizoanthus couchii* (Johnst.), (p. 644). Transverse section through the body-wall, $\frac{2}{B}$.

5. *Epizoanthus norvegicus* (Kor. & Dan.), (p. 650). Transverse section through the body-wall, $\frac{2}{B}$.

6. *Epizoanthus paguriphilus*, Verr. (p. 641). Transverse section through the body-wall, $\frac{2}{A}$.

7. *Epizoanthus arenaceus* (D. Ch.), (p. 649). Transverse section through the body-wall, $\frac{2}{B}$.

8. *Parazoanthus axinellæ* (Schmidt), (p. 654). Transverse section through the body-wall, $\frac{2}{B}$.

9. *Parazoanthus dixoni*, n. sp. (p. 658). Vertical section through the body-wall, $\frac{2}{B}$.

10. *Parazoanthus dixoni*. Transverse section through the body-wall, $\frac{2}{B}$.

11. *Parazoanthus anguicoma* (Norm.), (p. 656). Transverse section through the body-wall, $\frac{2}{B}$.

12. *Parazoanthus anguicoma*. Vertical section through the body-wall, $\frac{2}{B}$.

* These letters of magnification refer in all cases to Zeiss' system.

A. M. S. del ad nat.
M. P. Parker chr. lith.

West, Newman imp.

EXPLANATION OF PLATE LX.

PLATE LX.

LETTERING ADOPTED IN THE FIGURES.

cu.,	cuticle.
ect.,	ectoderm.
enc. sin.,	encircling sinus.
end.,	endoderm.
end. sph. m.,	endodermal sphincter muscle.
incr.,	incrustation.
m.,	mesoglœa.
m. cn. mes.,	macrocnemic mesentery (the sulco-sulcar lateral mesentery).
m. f.,	mesenterial filament.
m. sph. m.,	mesoglœal sphincter muscle.
nem.,	nematocyst.
œs.,	œsophagus.
œs. r.,	œsophageal ridge.
p. b. m.,	parieto-basilar muscle.
r. ect.,	reflected ectoderm.
r. end.,	reflected endoderm.
r. m.,	retractor muscle.
s. d.,	sulcar directive mesenteries.
sl. d.,	sulcular directive mesenteries.
s. gr.,	sulcar groove.
sp.	sperm-cell (testis).

Fig.

1. *Epizoanthus incrustatus* (Düb. & Kor.), p. 636). Transverse section through the œsophageal region of the column, $\frac{4}{a^{*}\ 10}$.

2. *Epizoanthus wrightii*, n. sp. (p. 651). Vertical section through the sphincter muscle, $\frac{2}{B}$.*

3. *Epizoanthus couchii* (Johnst.), (p. 644). Vertical section through the sphincter muscle, $\frac{2}{B}$.

4. *Epizoanthus arenaceus* (D. Ch.), (p. 649). Vertical section through the sphincter muscle, $\frac{2}{B}$.

5. *Epizoanthus paguriphilus*, Verr. (p. 641). Transverse section through a fertile mesentery, $\frac{4}{a^{*}\ 10}$.

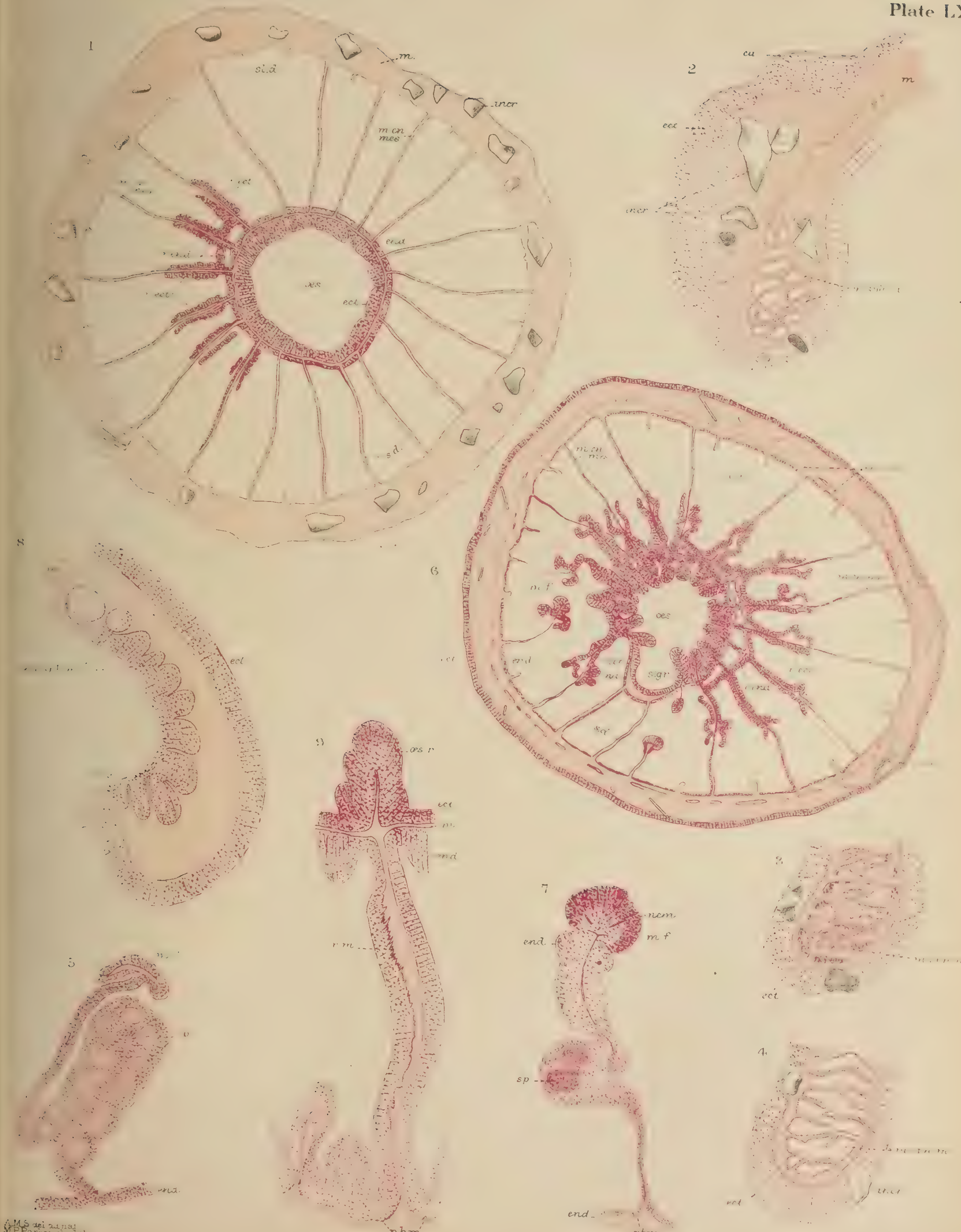
6. *Parazoanthus axinellæ* (Schmidt), (p. 654). Transverse section through the œsophageal region of the column, $\frac{4}{a^{*}\ 10}$.

7. *Parazoanthus axinellæ.* Transverse section through a fertile mesentery, $\frac{2}{B}$.

8. *Parazoanthus dixoni*, n. sp. (p. 658). Vertical section through the sphincter muscle, $\frac{2}{B}$.

9. *Parazoanthus dixoni.* Transverse section through a perfect and an imperfect mesentery, $\frac{2}{B}$.

* These letters of magnification refer in all cases to Zeiss' system.



A.M.S. del ad nat.
M.P. Parker chr lith.

West Newman imp.

XIII.

REPORTS ON THE ZOOLOGICAL COLLECTIONS MADE IN TORRES STRAITS BY PROFESSOR A. C. HADDON, 1888–1889.

ACTINIÆ: I. ZOANTHEÆ. By PROFESSOR ALFRED C. HADDON, M.A. (Cantab.), M.R.I.A., Professor of Zoology, Royal College of Science, Dublin, and MISS ALICE M. SHACKLETON, B.A. Plates LXI., LXII., LXIII., LXIV.

[Read November 19, 1890.]

The following is the first instalment of an investigation on the structure and systematic relations of the Actiniæ collected by one of us in Torres Straits. We decided to publish our account of the Zoantheæ first, as it is a well circumscribed group and admits of independent treatment. We took this opportunity of studying the British forms, and have thus had a considerable number of forms under examination at the same time. This has given us a personal knowledge of every genus except Mammilifera, of which genus no authentic specimens exist in any museum.

Our account of the British Zoantheæ is simultaneously published with this as "A Revision of the British Actiniæ," Part II.: The Zoantheæ (Trans. Royal Dublin Society, vol. iv., ser. ii.); and we would refer the reader to that Memoir for a general summary of the anatomy of the group, and a special account of that of the British representatives. We have also given a classification of the Zoantheæ, and as far as is possible have allocated all the species described by other authors to their proper genera. It is impossible at the present time to monograph this group, as there is such a general sameness in external character that it makes it difficult to seize on points which are of descriptive value. The present confusion in which this group lies is mainly due to this fact; the fault is that of the animals themselves rather than that of the zoologists who have described and named them. This similarity of appearance not only affects the species of a genus, but also the species of different genera. Thus it becomes a necessity for every species to be examined anatomically by means of microscopical sections, first to determine its genus, and secondly to discover accurate specific characters. Once a species is thoroughly

known it will generally be possible to identify other specimens belonging to that species by external characters only. Owing to the incrusted nature of most of the Zoantheæ it is very difficult to get satisfactory sections, and for the same reason spirit specimens are often apt to be badly preserved for histological purposes.

It is not unfair to point out that the disorder which has occurred in this group is also partially due to the fact that many zoologists have not paid due regard to the generally recognised rules of zoological nomenclature, and have not taken the trouble to thrash out the synonymy; and some have identified certain forms with pre-existing species in a rather reckless manner.

Owing to the lack of salient external characters, which could be observed in preserved specimens, we have not been able to give diagnostic names to most of the species, and we have consequently associated them with the names of zoologists who have collected in Torres Straits, or who have studied the group. The types of the species have been given to the British Museum, in which institution will also be found a complete set of slides illustrating the anatomy of all the forms described in this and in the preceding Memoir.

CLASSIFICATION OF THE GROUP.

ZOANTHEÆ.

Actiniæ with numerous perfect and imperfect mesenteries, and two pairs of directive mesenteries, of which the sulcar are perfect and the sulcular are imperfect. A pair of mesenteries occur on each side of the sulcular directives, of which the sulcular moiety is perfect and its sulcar complement is imperfect; a similar second pair occurs in one section of the group (Brachycneminæ), or the second pair may be composed of two perfect mesenteries (Macrocneminæ). In the remaining pairs of mesenteries, of both divisions, this order is reversed, so that the perfect mesentery is sulcar and the imperfect is sulcular. The latter series of mesenteries are bilateral as regards the polyp, and arise independently (*i.e.* neither in pairs nor symmetrically on each side) in the exocœle on each side of the sulcar directives, in such a manner that the sulcular are the oldest, and the sulcar the youngest. Only the perfect mesenteries are fertile, or bear mesenterial filaments. A single sulcar œsophageal groove is present; the mesoglœa of the body-wall is traversed by irregularly branching ectodermal canals, or by scattered groups of cells; the body-wall is usually incrusted with foreign particles. The polyps are generally grouped in colonies connected by a cœnenchyme, the cœlenteron of each polyp communicating with that of the other members of the colony by means of basal endodermal canals.

Family. ZOANTHIDÆ, Dana, 1846.

(With the definition of the group.)

Sub-family. BRACHYCNEMINÆ, Hadd. & Shackl., 1891.

Zoantheæ in which the sulcar element of the primitive sulco-lateral pair of mesenteries (cnemes) is imperfect:—

GENERA OF THE BRACHYCNEMINÆ.

ZOANTHUS,	Lamarck, 1801.
ISAURUS,	Gray, 1828.
(? MAMMILLIFERA,	Lesueur, 1817. (Not represented in Torres Straits).)
GEMMARIA,	Duchassaing et Michelotti, 1860.
PALYTHOA,	Lamouroux, 1816.
SPHENOPUS,	Steenstrup, 1856.

Sub-family. MACROCNEMINÆ, Hadd. & Shackl., 1891.

Zoantheæ in which the sulcar element of the primitive sulco-lateral pair of mesenteries (cnemes) is perfect:—

GENERA OF THE MACROCNEMINÆ.

EPIZOANTHUS,	Gray, 1867. (Not represented in Torres Straits).
PARAZOANTHUS,	Haddon & Shackleton, 1891.

Sub-family. BRACHYCNEMINÆ.

ZOANTHUS, Lamarck, 1801.

ZOANTHUS, Cuvier, 1817.

ZOANTHUS (RHYZANTHUS), Andres, 1884.

Brachycnemic Zoantheæ with a double mesoglœal sphincter muscle. The body-wall is unincrusted; the ectoderm is usually discontinuous; a well developed ectodermal canal system in the mesoglœa. Diœcious or monœcious. Polyps connected by a thin cœnenchyme.

Cuvier (**1798**) was the first to recognise some distinction between the Zoantheæ and other Actiniæ, but in an indefinite sort of way; he refers to "1. Le zoanthe à cinq pétales (*Actin. dianthus*); 2. Le zoanthe à drageons (*Actin. sociata*)."

Lamarck (Système, 1801) first divided the Actinæ into the genera Actinia and Zoantha; he says (**1801**, p. 363): "IIᵉ. genre. Zoanthe, Zoantha—*Zoantha sociata*, *Act. sociata*, Sol. et Ellis, *Hydra sociata*, Gmel."

Bosc (**1802**, p. 261) refers to "Zoanthe, Zoantha, Lam.; *Z. ellisii; Hydra sociata; Act. sociata*, S. & Ell."

Cuvier, in **1817** (p. 53), speaks of *Zoanthus sociatus*.

In Deshayes and Milne-Edwards' revised and augmented edition of Lamarck's Hist. des anim. sans vert. (**1836**, 2nd ed., p. 77), three species are acknowledged: "Zoanthe (Zoantha).—1. *Zoantha ellisii*, Bosc (*Act. sociata*, etc.); 2. *Zoantha solanderi*, Les.; 3. *Zoantha bertholetii*, Ehr."

Dana is the only later author who adheres to Zoantha instead of Zoanthus. According to the generally accepted rules of zoological nomenclature the Greek *ανθος* would have to be written *anthus*, it being agreed that, "in writing zoological names, the rules of Latin orthography must be adhered to."

TORRES STRAITS SPECIES OF THE GENUS ZOANTHUS.

Z. coppingeri, n. sp.
Z. jukesii, n. sp.
Z. macgillivrayi, n. sp.

Zoanthus coppingeri, n. sp.

(Pl. LXI., figs. 1, 2; Pl. LXII., fig. 1; Pl. LXIV., figs. 1–4.)

Form.—Body smooth, pyriform when contracted, rather elongated when expanded. Polyps in clusters, the buds springing from the bases of the polyps themselves; cœnenchyme, thin, encrusting. Tentacles, in two rows, similar.

Colour.—Pinkish below, greenish or bright green above, sometimes entirely pinkish; always with brown streak-like spots; disc, burnt sienna, with darker spots; rim of mouth, brown; tentacles, gray, with a single row of black spots; there is a black spot between each tentacle, and these are continued as black lines on the capitulum.

Dimensions.—Length of a contracted specimen, 15 mm.; diameter of upper portion, 5 mm.

Locality.—Fringing Reef, Mabuiag. Oct. 19, 1888. Numerous specimens.

We have named this species in honour of Dr. Coppinger, who, when surgeon on board H.M.S. "Alert," collected some marine zoological specimens from Torres Straits.*

Body-wall (Pls. LXII., LXIV.).—The wall of the column is bounded externally by a distinct cuticle. Between this cuticle and the ectoderm lies a thin peripheral layer of mesoglœa, the "subcuticula" of Andres and M^cMurrich. The ectoderm forms an almost continuous layer, but is crossed by numerous delicate strands of mesoglœa, which unite to form the peripheral layer. In addition to the ordinary columnar cells, nematocysts of an oval shape are present. Numerous branching and anastomosing canals arise from the ectoderm, and run through the mesoglœa, generally in a radial direction. They vary greatly in size. Sometimes they run along close to the endoderm, but we have never observed any connexion with it. Many of these canals pass into the mesenteries, where they form large sinuses. Nematocysts, similar to those in the ectoderm, are found in these canals. The mesoglœa, which constitutes the chief thickness of the body-wall, is homogeneous and clear, and is permeated by the usual minute cells, which are drawn into fine protoplasmic strands. These have a radial direction, and extend right across the mesoglœa, from endoderm to ectoderm. The endoderm is crowded with zooxanthellæ. There is a slight diffuse endodermal muscle.

Capitulum.—The ectoderm becomes continuous in the capitulum, and in contracted specimens is thrown into deep folds. Nematocysts are very numerous.

Sphincter muscle.—The double sphincter muscle is a powerful one, the upper portion being slightly shorter than the lower one (Pl. LXIV., fig. 3). It consists of numerous irregularly shaped cavities, the mesoglœa being arranged in complicated plaitings.

Tentacles (Pl. LXIV., fig. 2).—The ectoderm of the tentacles is normal and ciliated. The nuclei form a distinct central band in section. Outside the band are numerous, small, thin nematocysts, whilst between the band of nuclei and the mesoglœa small irregular cells may be discerned, which are probably nerve cells. There is a diffuse ectodermal muscular layer. The fibres, which are longitudinal in direction, are supported on simple plaitings of mesoglœa. The mesoglœa forms a thin layer without canals or enclosures of cells. The endoderm, which is crowded with zooxanthellæ, is very thick, so that the lumen of the tentacles is almost obliterated. Nematocysts, similar to those found in the capitulum and other parts of the ectoderm, are abundant in the endoderm of the tentacles. The endodermal muscle fibres are circular in direction.

* See "Report on the Zoological Collections made in the Indo-Pacific Ocean during the Voyage of H. M. S. 'Alert,' 1881–1882" (1884).

Disc.—The structure of the disc is very similar to that of the tentacles, but we have not found nematocysts in the endoderm of this region.

Œsophagus.—The ectoderm of the œsophagus forms a simple layer. The groove is visible, although not very well marked. The mesoglœa is extremely thin, and of uniform thickness.

Mesenteries.—The arrangement of the mesenteries is brachycnemic. They are coiled and folded, almost entirely filling up the body-cavity. The ectoderm of the œsophagus is reflected upwards and continued downwards into the mesenterial filaments, forming numerous folds along each mesentery (Pl. LXIV., fig. 4), in a manner which will be more fully described in our account of *Z. macgillivrayi.* The mesoglœa is extremely thin in the upper part of the mesentery, although thicker in the immediate neighbourhood of the wall, where it usually contains a "basal" canal. Lower down the mesoglœa is thicker throughout, and here the canal expands to form the large sinus, which, as we have previously mentioned, is connected with the ectodermal canal system of the body-wall (Pl. LXII., fig. 1). The endoderm of the mesenteries forms a deeper layer than that of the body-wall, and zooxanthellæ, though present, are not nearly so numerous. The nuclei of the columnar cells form a peripheral band, leaving a clear space next to the mesoglœa. Nematocysts are also to be found in the endoderm of this region. The parieto-basilar muscle is diffuse and feebly developed. The longitudinal muscle fibres are also very feeble, being scarcely discernible. There is no special thickening of the endoderm in the lower part of the mesenterial filaments as in *Z. macgillivrayi.*

Gonads.—The sexes are distinct. We have sections of both male and female specimens (Pl. LXIV., figs. 3, 4). The gonads appear to be distributed on the mesenteries in irregular rows.

Zoanthus jukesii, n. sp.

(Pl. LXI., figs. 3–5; Pl. LXII., fig. 2; Pl. LXIII., fig. 1.)

Form.—Body short and thick; body-wall smooth and delicate; cœnenchyme forming stolons: tentacles in two cycles of about 20–24 in each.

Colour.—Body and stolon translucent gray, the endoderm shining through with a brown tint (owing to the presence of zooxanthellæ); capitulum pink, with 24 dark lines; disc brown, with, usually, pairs of pale lines (mesenteries) for inner cycle of tentacles; mouth with greenish lip; œsophagus gray. Tentacles: inner cycle green, with dark rings or marks on the oral aspect; outer cycle opaque pale pink; all the tentacles with a dark spot at the tip; the base of the tentacles of the outer cycle is in some specimens tinged with green.

Dimensions.—Height 7–12 mm.; diameter of disc, 6 mm.

Locality.—Fringing Reef, Mer (Murray Islands), Jan. 29, 1889. Numerous specimens.

We associate this species with the name of the late Prof. Beete Jukes, at one time Professor of Geology in the Royal College of Science, Dublin, who was also the author of the interesting Voyage of the "Fly."* To this day the name of this genial naturalist is still remembered in the Murray Islands and in Erub.

Body-wall (Pl. LXII., fig. 2).—A cuticle and peripheral mesoglœa are present as in *Z. coppingeri.* The cells of the ectoderm are not distinct but appear to have become fused, as in the specimen of *Z. sociatus*, described by McMurrich (1889A, p. 63). For the most part they appear to form a quite continuous and narrow layer, but in some parts the contents of the cells, adhering closely to the mesoglœa on either side, leave an empty space, across which, irregularly placed and exceedingly delicate strands of mesoglœa are seen to pass. Anastomosing canals, connected with the ectoderm, are present, though not at all so numerous as in *Z. coppingeri.* Lacunæ, clearly of similar origin, but completely surrounded by the mesoglœa, are more frequently to be met with. The canals and lacunæ are most abundant in the lower part of the column, and here their connexion with the basal canals of the mesenteries can be demonstrated (Pl. LXII., fig. 2). The mesoglœa is of the usual character. Zooxanthellæ also abound in the endoderm of this species. There is a diffuse endodermal muscular layer, supported by acute mesogleal prominences.

Capitulum.—The ectoderm of the capitulum is thrown into folds, as in *Z. coppingeri*, and rather opaque oval cells, with a clear outline (probably nematocysts, are here very numerous, being generally embedded singly in in the mesoglœa.

Sphincter muscle.—The sphincter muscle is not so strongly developed as in *Z. coppingeri.* Of the two parts of the muscle the upper one is in this case the longer. The muscle cavities are larger and less filled up with cells, the plaitings of the mesoglœa being simpler than in *Z. coppingeri.*

Disc and tentacles.—The ectoderm of the disc and tentacles closely resembles that described for *Z. coppingeri.* The endoderm is crowded with zooxanthellæ, but contains no nematocysts.

The ectoderm of the œsophagus is thrown into slight folds. The groove is well marked (Pl. LXIII., fig. 1).

Mesenteries (Pl. LXIII., fig. 1).—The arrangement of the mesenteries is of the usual brachycnemic type. The reflected ectoderm of the œsophagus forms a smaller

* Narrative of the Surveying Voyage of H. M. S. "Fly," commanded by Captain F. P. Blackwood, R.N. (during the years 1842–1846). 1847. By J. Beete Jukes.

number of folds than in the last species described. The mesenterial filaments also appear shorter in transverse section. The mesoglœa is thicker throughout, and usually contains more than one canal in each mesentery.

These canals appear to run from the base of the mesenteries to the œsophageal region. Near the base they appear to be connected with ectodermal spaces in the body-wall. The endoderm of the mesenteries is very similar to that of the body-wall.

The longitudinal muscles are better developed than in *Z. coppingeri*, the mesoglœa being thrown into slight plaitings to support the fibres. The parieto-basal fibres, though distinct, are rarely supported by plaitings.

Gonads.—The sexes appear to be distinct in this species also. All the specimens examined by us containing mature reproductive organs were female. The gonads are irregularly arranged as in *Z. coppingeri*.

This species somewhat resembles the preceding one; spirit specimens can be distinguished externally by the following characters:—*Z. coppingeri* is larger; markedly pyriform when contracted, and the brown spots persist (for at least three years).

Zoanthus macgillivrayi, n. sp.

(Pl. LXI., fig. 6; Pl. LXII., fig. 3; Pl. LXIII., fig. 2; Pl. LXIV., figs. 5–8).

Form.—Body smooth, transversely wrinkled, with a thick cuticle, upper part of column slightly swollen, disc large; tentacles small, 32 in number, in two cycles; mouth very small. The capitulum in expanded specimens exhibits two encircling grooves, which indicate the double sphincter muscle, cœnenchyme forming a flattened stolon.

Colour.—Not determined when alive; yellowish in alcohol.

Dimensions.—Height of large specimens, 18 mm.; average diameter of colour, 3 mm.; diameter of disc, 6.5 mm.

Locality.—Fringing reef, Mabuiag, Sept. 21, 1888. Six specimens.

We acknowledge in the specific name we have given to this species the zoological labours in Australasia of the late J. Macgillivray, author of the valuable "Voyage of the Rattlesnake."*

Body-wall.—The wall of the upper part of the column is comparatively thin. Lower down it is much thicker. The cuticle is thick, and foreign bodies,

* Narrative of the Voyage of H. M. S. "Rattlesnake," commanded by the late Captain Owen Stanley, R.N., F.R.S., during the years 1846–1850 (1852).

foraminifera, diatoms, &c., are occasionally to be found embedded in it, and in the peripheral layer of mesoglœa. The latter can be very distinctly seen in this species. As in *Z. jukesii* the cells of the ectoderm appear to have become fused, and crossing strands of mesoglœa can only be seen in those few places where the ectodermal space is nearly empty. Anastomosing ectodermal canals, very similar to those found in *Z. coppingeri*, run through the mesoglœa and are connected with the basal canals of the mesenteries near the union of the column with the cœnenchyme (Pl. LXII., fig. 3). The surface of the column is thrown into numerous folds, which appear in cross-section as deep ectodermal bays lined with cuticle.

Sphincter muscle.—The sphincter muscle is somewhat similar to that in *Z. jukesii*, the upper being the longer of the two parts (Pl. LXIV., fig. 5). The cavities are simpler than in *Z. coppingeri*, but they are not so large as in *Z. jukesii.*

Disc and tentacles.—The structure of the disc and tentacles is very similar to that of the preceding species. There are no nematocysts in the endoderm.

Œsophagus.—There is a well marked œsophageal groove.

Mesenteries.—Of the two specimens which we have cut transversely, one shows the usual brachycnemic arrangements. In the other there are four imperfect mesenteries at the sulcular side of the œsophagus, instead of the usual pair of imperfect directives. The reflected œsophageal ectoderm and the structure of the mesenterial filaments can be well studied in this species. As can be seen in a longitudinal section, such as that figured (Pl. LXIV., fig. 5), the ectoderm of the œsophagus passes continuously on to the mesentery, where it suddenly becomes greatly thickened, and is thrown into transverse folds, the whole thickening having a crescentic form, first curving upwards and then downwards, losing itself, in the mesenterial filament. The ectoderm is reflected on both sides of every one of the perfect mesenteries, presenting in transverse section a characteristic pinnate appearance (Pl. LXIV., fig. 6). As above mentioned, the reflected ectoderm passes gradually into the mesenterial filament, the characteristic V shape of the latter (Pl. LXIV., fig. 7) being continuous with the peripheral folds of the former. The lateral elements of the mesenterial filaments gradually become shorter, so that as it descends only the median portion is left. Numerous nematocysts are found in this lower portion of the filament (Pl. LXIV., fig. 8). In this species the mesenterial filaments are confined to the upper part of the column, gradually disappearing about the middle of the column. As the filaments disappear the mesenteries also become much narrower (appearing in transverse section to shorten), projecting but a little way into the cœlenteron (Pl. LXIII., fig. 2). Lower down they again widen and project further, finally uniting in the centre at the base of the polyps to form the cœlenteric canals of the stolon (Pl. LXII., fig. 3). The mesoglœa of the mesenteries is well developed, especially near the base.

Canals are present from the œsophageal region downwards, frequently two or three in the perfect mesenteries. These canals are connected with the canals of the body-wall at the base of the column. Nematocysts are numerous in the endoderm of the mesenteries. The longitudinal muscle fibres form a simple layer, the parieto-basal muscles are better developed and supported upon slightly branched plaits of mesoglœa.

Gonads.—No gonads were present in the specimens we examined.

This species cannot be mistaken for either of the two previously described.

ISAURUS, Gray, 1828.

ANTINEDIA, Duch. & Mich., 1866.
POLYTHOA (MONOTHOA) (pars), Andres, 1884.
ZOANTHUS (MONANTHUS) (pars), Andres, 1884.

Large brachycnemic Zoantheæ with a single mesoglœal sphincter muscle. The body-wall is unincrusted; the ectoderm discontinuous; ectodermal and endodermal bays and small canals in the mesoglœa. Monœcious or diœcious. Polyps in small clusters or solitary.

The genus Isaurus was established by J. E. Gray in 1828 (Spic. Zool., 1828, p. 8) to include a species not before described, specimens of which from an unknown locality were in the British Museum. He named this species *Isaurus tuberculatus* on account of the tubercles on its surface. The name Isaurus is a Latinized version of Isaure, a name applied by Savigny (Description de l'Egypte, Polypes, pl. 2, figs. 1–4, 1811, ined.) to four species figured by him in 1811, and supposed by Gray to be of the same genus as his *I. tuberculatus*. Savigny published, however, neither the characters of the genus nor descriptions of the species. Lamouroux mentions the genus as Isaura, but neither does he define it in any way.

The genus Isaurus must therefore be regarded as Gray's, and *Isaurus tuberculatus* as the type species.

In 1860 Duchassaing and Michelotti found specimens at St. Thomas and Guadaloupe, which closely agreed with Gray's account of *Isaurus tuberculatus*. Although unaware of the existence of Gray's species, they gave to their specimens the same specific name, calling them *Zoanthus tuberculatus*, and subsequently in 1864 (forming for the species a new genus), *Antinedia tuberculata*. Andres considered that Gray's *I. tuberculatus*, and Duchassaing and Michelotti's *A. tuberculata*, were distinct species, and consequently renamed the latter *A. duchassaingi*.

In 1889 M^cMurrich described specimens from the Bermudas, evidently belonging to Gray's species and also agreeing closely with *A. tuberculata*, Duch. & Mich., which he considers to be identical with it. Anatomical examination of these specimens showed that they possessed most of the characters which Erdmann has ascribed to the genus Mammillifera. M^cMurrich therefore identified his specimens as *Mammillifera tuberculata* (Gray).

From Erdmann's Paper, however, we cannot find that he has sufficient reasons for concluding that the characters attributed by him to Mammillifera are possessed by any of the species for which that genus was erected by Lesueur in 1817. The specimens found by Erdmann in the museum at Bonn, from which he deduced these generic characters, were not referred to any species.

The generic name Mammillifera was adopted in 1817 by Lesueur for two species from the West Indies, named by him *M. auricula* and *M. nymphæa*. His definition of the genus is "A large cuticular expansion serving as a base for numerous animals, which, when contracted, assume the form of mammæ" (p. 178). From the dimensions given by Erdmann for his unnamed specimen, it seems possible that it agrees to some extent with this description, but the same might be said of *Zoanthus jukesii;* whilst both Gray's *I. tuberculatus* and our *I. asymmetricus* entirely disagree with it in outward form. It therefore appears that it is impossible to determine the true characters of the genus Mammillifera until the type species *M. auricula* has been recovered and submitted to anatomical examination. Until this is done we must therefore retain the name Isaurus for those species which undoubtedly belong to the same genus as *I. tuberculatus* and *I. asymmetricus.*

Although, as above stated, Gray instituted the genus Isaurus for *I. tuberculatus*, we find that in 1867 (P. Z. S., p. 234) he erects a new genus, Pales, for a closely allied form. In his "Solitary, rarely irregularly aggregate" division of the "*Zoanthi malacodermi*, or soft-skinned Zoanthi, or Zoanthinæ," he recognises three genera: "ISAURUS, Gray, Spic. Zool., 8, 1825 [the copy we have seen is dated 1828] ? Orinia, Duchassaing and Michelotti, Mém. Coral. des Antilles, 54. Pales [which he defines thus]—Body cylindrical, isolated, solitary, clustered, or sometimes proliferous, but each specimen having a separate base; outer skin smooth, thin, olive-brown, slightly concentrically wrinkled; the tentacles numerous, the internal laminæ numerous, slender, only slightly elevated, straight and parallel above, with a thickened edge, and sinuous below. *Pales cliftoni* (fig. 1, p. 236)—Hab. Western Australia (Mr. Clifton). The bodies are from $\frac{1}{3}$ to $\frac{1}{2}$ inch in diameter; but they vary greatly in length, some being as much as 2 inches long; but the general length [in spirits] seems to be about an inch. . . . . They are found attached to shells, both isolated and in clusters, and the larger ones are attached to the base of each other, forming a somewhat stellate cluster, as if they were free, floating in the sea."

It seems probable that the two genera are coterminous, and, if so, *I. cliftoni* will rank as a second Australian species of Isaurus.

In 1877 Andres described (p. 226) a new genus and species, *Panceria spongiosum* from Port Natal; but in 1884 (p. 315) he abandoned the genus, and re-named it *Polythoa* (*Monothoa*) *spongiosa*. We regard this as belonging to the genus under discussion.

TORRES STRAITS SPECIES OF THE GENUS ISAURUS.

I. asymmetricus, n. sp.

Isaurus asymmetricus, n. sp.

(Pl. LXI., figs. 7–9; Pl. LXII., fig. 4; Pl. LXIII., figs. 4–6; Pl. LXIV., fig. 9.)

Form.—Body elongated; upper portion of column, in retracted specimens, with usually four rather irregular longitudinal rows of tubercles, arranged in such a manner that there is a longitudinal area free from them. In some specimens there are intermediate tubercles, which may even form one or two rows. Young specimens are entirely smooth. The smooth side is somewhat shorter than the tuberculated, so that the body bends over to the former, and the introverted mouth is rarely terminal. The contracted capitulum exhibits radiating furrows from 18 in number upwards.

The polyps grow either singly or in small clusters. In the latter case there is a common, firm, fleshy, incrusting cœnenchyme, occasionally forming stolons, from which new buds arise.

Colour.—Whitish below, passing into brownish above; the darker portion is variously mottled with cream, or greenish cream, and occasionally diversified with darker spots; the tubercles are somewhat pinkish in colour.

Dimensions.—Average size of retracted specimens, 45 mm. in length; greatest diameter, 7 mm. The longest specimen measured 56 mm. in length when retracted.

Locality.—Torres Straits; on fringing reef between tides, Mabuiag, Oct., 1888, numerous specimens; 15–20 fathoms, between reefs, Murray Islands, Jan. 5, 1889, two specimens.

The specific name is derived from the marked asymmetry of the polyp. It is undoubtedly nearly allied to the *Mammillifera tuberculata* of McMurrich (1889, p. 117). The specific differences are the lesser number and greater size of the tubercles, though their diameter is about the same, and their asymmetrical arrangement; the height of our species is about double that of the West Indian form.

Our deeper water specimen was shorter and relatively much more tuberculated. In the "Special volume of the Proceedings of the Geographical Society of Australasia" (Sydney, 1885), under a section designated as "New Guinea Exploration," there is a letter from Dr. J. W. Haacke, concerning a collection of Anthozoa from Thursday Island, Torres Straits, in which he refers to "a species belonging probably to a new genus closely allied to the genera Polythoa and Zoanthus. This genus would be characterized by showing, even externally, a very obvious bilateral symmetry, better, I believe, than any other Anthozoon" (p. 225). There is no doubt that this is our new species.

We have copied Gray's account of the other Australian representative in our account of the genus, the absence of tubercles readily distinguishes it from our species. The same also holds good for the Port Natal species, *I. spongiosa.*

Body-wall (Pl. LXII., fig. 4).—The thick body-wall is covered by a cuticle as in the species of Zoanthus described. The ectoderm is not continuous, but is broken up into fairly uniform groups of cells by well developed strands of mesoglœa, which connect the peripheral with the general mesoglœa (Pl. LXIII., fig. 6). Amongst the ordinary columnar cells of the ectoderm are to be found numerous zooxanthellæ, as well as occasional large nematocysts. Bays of ectoderm, in which the cuticle may to a greater or less extent be involved, often occur. Canals and lacunæ of much smaller diameter than the anastomising canals which occur in the species of Zoanthus we have described, are also present. Some of these can be shown to be continuous with the ectoderm, whilst others have an equally clear connexion with the endoderm (Pl. LXIII., fig. 5). Endodermal bays, which may be quite shallow, or may extend to a greater or less extent into the mesoglœa as large open canals, are not unfrequent (Pl. LXII., fig. 4; Pl. LXIV., fig. 9). Occasionally these are slightly branched. A few nematocysts, smaller than those found in the ectoderm, as well as zooxanthellæ, are present in the endoderm. The endodermal muscular layer is well developed.

Sphincter muscle.—The single mesoglœal sphincter muscle is extremely thick and powerful. The cavities are well filled with muscle cells (Pl. LXIII., fig. 4).

Capitulum.—The cuticle and peripheral layer of mesoglœa, as well as the strands of mesoglœa which break up the ectoderm, are present in that part of the capitulum, which in contracted specimens is thrown into folds, but the cuticle disappears, and the ectoderm becomes continuous as the tentacles are approached.

Disc and tentacles.—The usual small nematocysts are found in the outer part of the ectoderm of the tentacles. The nuclei do not form a distinct central band, but are diffused, leaving, however, a clear band next to the muscle fibres. The ectodermal muscular layer is remarkably well developed. The fibres are supported on fine and complicated mesoglœal plaitings, forming in some cases a band nearly equal to one-third of the entire thickness of the wall of the tentacle.

In some places these plaitings appear to unite to form a distinct band of mesoglœa, outside the muscle fibres, so that here the muscle may be regarded as mesoglœal. The endodermal muscular layer is well developed, especially at the bases of the mesenteries, but it is not at all so remarkable as is that of the ectoderm. The endoderm, as well as mesoglœa, is relatively thin in the tentacles. The endoderm contains numerous zooxanthellæ.

Œsophagus.—The ectoderm of the œsophagus is thrown into slight and irregular folds. The groove is only indicated by a slight depression in the region of the sulcar directives. Both mesoglœa and endoderm form very thin layers. Nematocysts are present in the endoderm similar to those found in the endoderm of the mesenteries and column in this region.

Mesenteries.—The arrangement of the mesenteries is brachycnemic. The imperfect mesenteries are well developed, sometimes extending about half way from the body-wall to the œsophagus (Pl. LXIV., fig. 9). The ectoderm of the œsophagus is reflected a short way above the lower opening of the œsophagus, and forms the mesenterial filaments in the usual way. The mesoglœa of the mesenteries is comparatively well developed even in the œsophageal region, but it becomes much thicker as it descends. Several canals run vertically through each mesentery. Some of those appear to be connected in the cœnenchyme with the endoderm (Pl. LXIII., fig. 5). It is possible that others are connected with ectodermal canals or lacunæ, but we have not been able to trace any to the ectoderm. The endoderm of the mesenteries is very similar to that of the body-wall. It contains numerous small oval nematocysts. The muscles are fairly well developed. The mesoglœa on each side of the mesentery, close to the body-wall, is thrown into numerous and often branching plaits, which support the fibres of the parieto-basilar muscle (Pl. LXIV., fig. 9). On one side of each mesentery the mesoglœa is thrown into very slight plaits all the way up. These plaits support the longitudinal fibres. On the other side, the parieto-basilar fibres (cut obliquely in transverse section) extend considerably beyond the mesoglœal plaitings. In the imperfect mesenteries the mesoglœal plaitings extend the whole way on both sides, and it is hardly possible to distinguish two distinct sets of fibres.

Gonads.—In only one of our specimens did we find gonads. These were all female; but they were few and not fully developed. We cannot say with certainty whether this species is monœcious or diœcious, though our evidence leads us to suppose it to be the latter.

Gemmaria, Duch. & Mich., 1860.

Solitary brachycnemic Zoantheæ with mesoglœal sphincter muscle. The body-wall is incrusted with grains of sand and spicules. The ectoderm is usually

discontinuous, but may be continuous. Lacunæ and cell-islets are found in the mesoglœa. Diœcious.

This genus was recovered by M'Murrich (**1889**), who identified a Zoanthid from the Bermudas as *Gemmaria rusei*, Duch. & Mich. (p. 124), and in a previously written, but subsequently published, Paper (**1889A**, p. 65), he describes *G. isolata*, n. sp., from the Bahamas. We are able to extend the geographical distribution of the genus, and at the same time give ourselves the pleasure of associating one of our new species with the name of our esteemed colleague, Prof. J. Playfair M'Murrich, of Haverford College, Pa., U. S. A., to whom we have so often referred in these pages.

Besides the type species, *G. rusei*, from St. Thomas, Duchassaing and Michelotti (**1860**) describe *G. clavata*, Duch. (St. Thomas and Guadeloupe), *G. swiftii*, D. & M. (St. Thomas), and *G. brevis*, Duch. (Antilles).

In 1866 they state that "perhaps *G. swiftii* may be better placed in the genus Bergia." From the figure (**1860**, pl. viii., pp. 17 and 18) it appears to closely resemble a Sarcodictyon, but in the later Memoir the authors state that it has 24 biserial tentacles. It is certain that this is not a synonym for *Parazoanthus axinellæ*, as Andres suggests (**1884**, p. 311). Anyhow it is clear that these authors had no very definite conception of their own genus, for neither *G. swiftii* nor *G. brevis* would appear to belong to the same genus as the type species, nor is it certain that *G. clavata* does either.

It is difficult to understand why Andres (**1884**, p. 318) has regarded *G. brevis* as a synonym of two or three species of Epizoanthus. Gray (**1867**, p. 238) has added to the confusion by placing *Z. sulcatus*, Gosse, in this genus; but it is probable as M'Murrich suggests, that *Triga philippinensis*, Gray (**1867**, p. 239), may belong to the genus in question. Gray's description of the genus Triga:—"The coral sub-cylindrical, solitary, attached, with a rather expanded base; outer coat coriaceous, sandy, concentrically wrinkled"; and of the type species:—"Coral sub-cylindrical, clavate, rather narrowed near the base, concentrically wrinkled; end convex, obscurely radiately striated; hab. Philippines, attached to small pebbles (*Cuming*). The coral varies from an inch to an inch and a-half in length"—agrees very well, except for size, with our new species; but without microscopical examination it would be impossible to determine with certainty even the genus of Gray's species.

The only known species of this genus are *G. rusei*, D. & M., *G. isolata*, M'M., *G. macmurrichi*, n. sp., and *G. mutuki*, n. sp.

TORRES STRAITS SPECIES OF THE GENUS GEMMARIA.

G. macmurrichi, n. sp.
G. mutuki, n. sp.

Gemmaria macmurrichi, n. sp.

(Pl. LXI., fig. 11; Pl. LXIII., fig. 7.)

Form.—Erect, rigid, wider above than below; upper portion of contracted specimen with minute radiating corrugations.

Colour.—Sandy.

Dimensions.—Height, 13 mm.; diameter, 3·5 mm. above, 2 mm. below.

Locality.—Channel between Mer and Dauar, Murray Islands. 20 fathoms. Mar. 16, 1889. One specimen only.

Body-wall (Pl. LXIII., fig. 7).—The ectoderm is discontinuous, being broken up by thick, irregular strands of mesoglœa, which unite to form a distinct peripheral layer lying beneath the cuticle. The ectodermal cells are for the most part disintegrated in our specimen, their contents adhering to the surrounding mesoglœa and leaving an empty space in the centre. The incrustations consist chiefly of coarse grains of calcareous sand, but a few silicious sponge spicules are also present, and are left after decalcification. Beneath the incrustations lies an encircling sinus, which is, however, so much interrupted by the mesoglœa as to appear in horizontal section as a circular series of lacunæ, each lacuna lying immediately below the union of a mesentery with the body-wall, two or three lacunæ being occasionally united by a fine canal. As the base of the polyps is approached the lacunæ gradually become smaller and finally disappear. It thus appears that the body-wall is pierced by a number of canals, which run vertically upwards from near the base to the disc of the polyps; these canals being occasionally connected with each other by much finer crossing canals. Similar fine canals are occasionally to be found running from the vertical canals outwards towards the ectoderm. Cell islets are scattered abundantly through the mesoglœa, as also are single cells elongated into delicate fibrils connected both with endoderm and mesoglœa, such as we have described in other species of Zoantheæ. Large lacunæ, densely filled with deeply staining granules, are numerous at the base of the polyp. These are clearly connected with the mesenterial canals which arise in this region. They seem to be of ectodermal origin. The endoderm which lines the column is not very well preserved, but it appears to form a regular layer of medium thickness. The muscular layer is well developed in the upper part of the column. Lower down it is weaker.

Sphincter muscle.—The sphincter muscle is single, mesoglœal, and is well developed.

Disc and tentacles.—Unlike the two species of Gemmaria described by McMurrich, the ectoderm of the disc and tentacles contains no zooxanthellæ, nor have we observed them in the endoderm either. The ectodermal muscular layer is fairly

well developed in our specimen, whilst in his it is very weak (1889, p. 124). Cell enclosures (similar to those described and figured by McMurrich) are found in the disc of *G. macmurrichi.* Foreign bodies are occasionally found embedded in the mesoglœa of this region.

Œsophagus.—The tissues of the œsophagus are badly preserved in our specimen. There is a slight thickening of the mesoglœa at the groove, but we are unable to give further particulars.

Mesenteries.—The mesenteries are arranged as in other Brachycneminæ. The mesoglœa is well developed in both imperfect and perfect mesenteries. The muscular layer appears to be feebly developed, the mesoglœal plaitings not being well marked. A vertical canal runs through each mesentery, from the base of the polyps to the disc; in many cases it appears to divide, giving rise to two or more canals in the œsophageal region. The reflected ectoderm and the filaments are so badly preserved that it is impossible to make out the particulars of their arrangement. The endoderm of the mesenteries is very similar to that which lines the body-wall.

Gonads.—There were no gonads in our specimen.

This species can easily be distinguished anatomically from the two species investigated by McMurrich, but externally they appear to be very similar.

Gemmaria mutuki, n. sp.

(Pl. LXI., fig. 10.)

Form.—Erect, wider above than below; upper portion of retracted specimens with a large number (24–30) of fine radial ridges, which are continued some way down the column; lower portion of column wrinkled in spirit specimens. Basal gemmation occurs.

Colour.—Grayish-white in spirit.

Dimensions.—Height, 10–12 mm.; average diameter, 4.5 mm.

Locality.—Mabuiag, 6th October, 1888; 5 specimens.

We have named this species after a local hero, Mūtūk by name, whose adventures are recorded in the Journal of the Folk-lore Society, "Folk-lore," I., 1890, p. 56.

Body-wall (fig. 1, p. 690).—The ectoderm is continuous, and is covered by a thin cuticle to which numerous diatoms adhere. Occasional zooxanthellæ are to be found in the ectoderm. The mesoglœa is rather thin relatively to the diameter of the polyp. Numerous incrustations are embedded in the mesoglœa. They are chiefly spicular; ascidian as well as sponge spicules being frequently found. Grains of sand are

also present. Cell enclosures consisting for the most part of lacunæ are very numerous in the mesoglœa. There is no regular series of canals or of lacunæ lying at the union of each mesentery with the body-wall, such as we have described for *G. macmurrichi*. In some parts of the wall, the lacunæ lie so close together beneath the incrustations, as to suggest an interrupted encircling sinus; but for the most part they are irregularly scattered through the mesoglœa. Zooxanthellæ are found in many of these lacunæ. The endoderm forms a uniform layer of moderate thickness in which zooxanthellæ are very numerous. The muscular layer is well developed.

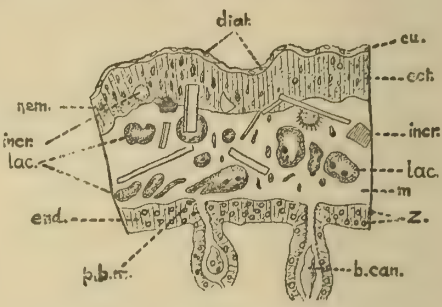


Fig. 1.—*Gemmaria mutuki.* Transverse section of body-wall.

Sphincter muscle.—The usual single mesoglœal sphincter muscle is present.

Disc and tentacles.—As in the body-wall, zooxanthellæ are present in both ectoderm and endoderm in this species, though they are much less abundant in the former than in the latter layer. The ectodermal muscular layer is rather weak. In both these features it will be seen that *G. mutuki* differs from *G. macmurrichi*, and resembles McMurrich's two West Indian species. The mesoglœa of the disc in this species also contains cell enclosures.

Œsophagus.—The groove is well marked, and of the truncated form described and figured by McMurrich for *G. isolata* (**1889** A, p. 66, Pl. IV., fig. 20).

Mesenteries.—The mesenteries have the usual brachycnemic arrangement. The mesoglœa is fairly well developed; the musculature is rather weak. Each mesentery contains a single basal canal, which does not divide in the œsophageal region as in *G. macmurrichi*, but runs up vertically from the base of the polyp almost to the disc. The tissues in the lower part of the cœlenteron in our specimen are unfortunately not sufficiently well preserved for us to give details regarding the mesenterial filaments.

Gonads.—Numerous ripe sperm cells are present in the cœlenteron of the specimen cut by us.

Externally this species may be distinguished from *G. macmurrichi* by its shorter, more stumpy form. Anatomically it differs from *G. macmurrichi* in the presence of numerous zooxanthellæ, in the continuous ectoderm, and in various other points, which will be seen by comparing our description of the two species. Outwardly, *G. mutuki* may also be readily distinguished from the two West Indian species, but in several anatomical points, referred to above, it seems to agree more nearly with them than with *G. macmurrichi*.

PALYTHOA, Lamx., 1816.

CORTICIFERA, Lesueur, 1817. POLYTHOA, Andres, 1884.

MAMMILLIFERA (pars), Blainville, 1830. POLYTHOA (CORTICITHOA), Andres, 1884.

Brachycnemic Zoantheæ with a single mesoglœal sphincter muscle. The body-wall is incrusted. The ectoderm is continuous (?); the mesoglœa contains numerous lacunæ, and occasionally canals. Diœcious. Polyps immersed in a thick cœnenchyme, which forms a massive expansion.

The genus Palythoa was founded by Lamouroux (**1816**, p. 359) for the reception of two species which had previously been described and figured by Ellis and Solander as *Alcyonium mammillosum* and *A. ocellatum* (**1786**, pp. 179, 180, Pl. I., figs. 4–6). Palythoa is thus defined by Lamouroux :—"Polypier en plaque étendue, couverte de mamelons nombreux, cylindriques, de plus d'un centimètre de hauteur, réunis entre eux; les cavités ou cellules isolées, presque cloisonnées longitudinalement et ne contenant qu'un seul polype."

Palythoa mammillosa is evidently regarded by Lamouroux as the type species of the genus. He reproduces Solander's figure of this species, but not that of *P. ocellata*, of which he merely gives a description. Unfortunately a Latinized version of the French name "Palythoé Etoillée," given by Lamouroux to *P. mammillosa*, has been added at the bottom of his plate—a circumstance which has given rise to some confusion.

In 1817 Lesueur, being evidently unacquainted with Lamouroux's work, erected the genus Corticifera for two West Indian species which he named *C. glareola* and *C. flava.* These species are evidently very nearly allied to *P. mammillosum* and *P. ocellata:* indeed Lesueur queries whether *C. flava* is not synonymous with *Alcyonium ocellatum*, Ellis and Sol.; and his definition of the genus Corticifera agrees very nearly with that of Lamouroux for Palythoa.

Subsequent naturalists have, with very few exceptions, recognized the priority of Lamouroux's genus, and have applied the name Palythoa to all those Zoantheæ which are incrusted with sand, and are immersed to a greater or less extent in the cœnenchyme, forming corticiferous expansions. In this sense Verrill used the term in 1869, and Hertwig in 1882 adopted the same classification.

Unfortunately the genus Palythoa has also been occasionally extended to include Zoantheæ which are incrusted with sand, but which are united only at the bases, forms which are included in the genus Epizoanthus, as defined by Verrill (**1869**, p. 437). Amongst the species to which the name Palythoa was thus mistakenly applied was a form with ribbon-like cœnenchyme and exsert polyps, described by Schmidt as *P. axinellæ* (**1862**, p. 61).

In 1885 Erdmann, investigating the anatomy of a number of forms which, to judge from their outward characters, should all be relegated to the genus Epizoanthus, discovered that, in reality, they belonged to two distinct natural genera, distinguished by the circumstance that some of them possessed a single mesoglœal sphincter muscle, whilst in others the sphincter was endodermal. Amongst the latter was Schmidt's species *P. axinellæ*. Those species which possessed a mesoglœal sphincter muscle Erdmann retained in the genus Epizoanthus. Those which had an endodermal sphincter, he placed in the genus Palythoa, ignoring *P. mammillosa*, and adopting *P. axinellæ* as typical of the genus, thereby excluding the type species, as well as numerous closely allied forms which had hitherto borne the name *Palythoa.*

It was now necessary to find another name for these forms, and Erdmann consequently revived Lesueur's genus Corticifera, a genus which, as we have pointed out above, was synonymous with Palythoa, but had to give place to that genus on the grounds of priority. To the former definition of the genus Corticifera Erdmann added certain anatomical characters—namely, the "microtypal" (brachycnemic) arrangement of the mesenteries and the presence of a single mesoglœa sphincter muscle. These anatomical characters have been shown to be present in all the species recently investigated which are included in Lamouroux's Palythoa and in Lesueur's Corticifera, including the type species *C. glareola* (re-examined by McMurrich, **1889**, p. 122). It therefore appears that they all belong to one and the same morphological genus, which, as we have shown, must, according to the laws of priority, be known as Palythoa. To sum up, the argument may be briefly stated as follows :—Palythoa, Lamx. = Corticifera, Les. = Palythoa, Verrill, &c. Schmidt and others extended Palythoa to include *P. axinellæ* and similar species, thus, unconsciously, making the genus Palythoa both macro- and brachycnemic.

Erdmann restricted the genus Palythoa to the non-typical macrocnemic extension, and revived Corticifera for the typical brachycnemic species. We restore Lamouroux's genus, discard Corticifera, and erect a new genus, Parazoanthus, for *P. axinellæ* and allied species.

As regards *P. mammillosa*, the type species of Palythoa, we may say that we are strongly inclined to regard *C. lutea* of Hertwig (**1888**, p. 44, Pl. I., fig. 6) as being synonymous with *P. mammillosa.* McMurrich agrees with us in regarding Hertwig's identification of his West Indian form with Quoy and Gaimard's *Mammillifera lutea*, from the Fiji Islands, as doubtful in the extreme; but he is inclined to believe Hertwig's species to be identical with *C. glareola*, which he describes (**1889**, p. 122). However this may be, we feel quite justified in assuming that the anatomical characters of *P. mammillosa* are similar to those of all the other species possessed of similar outward characters, which have been anatomically examined.

TORRES STRAITS SPECIES OF THE GENUS PALYTHOA.

P. howesii, n. sp.
P. kochii, n. sp.
P. cæsia (?), Dana.

Palythoa howesii, n. sp.

(Pl. lxi., fig. 13; Pl. lxiii., fig. 8.)

Form.—Polyps scarcely projecting above the surface of the cœnenchyme when contracted, and then, in most cases, only the one side is prominent; in other words, the side is almost invariably entirely sunk. Cœnenchyme, thick, incrusting. The polyps are arranged in indefinite, roughly parallel rows. Owing to the partial immersion of the polyps the prominent portions of contiguous polyps have a tendency to form zigzag lines. The whole surface is very rigid and rough, owing to the incrustation of sandy particles.

Colour.—Sandy.

Dimensions.—Average diameter of polyps, 7 mm.

Locality.—Fringing reef, Thursday Island. One colony.

Named after Prof. G. B. Howes, of the Royal College of Science, London. [I would like to take this opportunity of acknowledging the assistance which my friend Professor Howes has rendered me from first to last in the storing and distribution of my Torres Straits collections.—A. C. H.]

Body-wall (Pl. lxiii., fig. 8).—As in other species of Palythoa, the body-wall and cœnenchyme are indistinguishable. The ectoderm which covers the surface of the colony is much torn, fragments of it alone adhering to the mesoglœa; these pieces are further broken by irregular projections of the mesoglœa, which somewhat resemble the mesoglœal strands found in various other species of Zoantheæ, but they do not appear to unite in this case to form a peripheral layer of mesoglœa. In most cases no cuticle is to be seen, but in one or two places we have found a thin cuticle, and it seems probable that in a normal condition such a cuticle covers the surface of the ectoderm. The mesoglœa is very thick, and the incrustations are chiefly found in the outer portion. The incrustations consist of coarse grains of sand, and are very numerous. Lacunæ, some of which are clearly connected with the ectoderm, are scattered through the mesoglœa. In some cases

the canals in the mesenteries, which are extremely well marked, are distinctly connected with the spaces in the body-wall. Large yellowish nematocysts are present in the outer ectoderm, in many of the lacunæ of the mesoglœa, and in the mesenteric canals, being especially numerous in the latter. A very few zooxanthellæ are also present. Besides the lacunæ, numerous isolated cells are enclosed in the mesoglœa, many of them being drawn out into the fine protoplasmic threads found in other species of Zoantheæ. The endoderm is granular, of uniform thickness, and contains occasional zooxanthellæ. The usual diffuse muscular layer is present.

Sphincter muscle.—The single mesoglœal sphincter muscle is well developed.

Disc and tentacles.—The ectoderm is thick, and in the tentacles the ectodermal muscular layer is well developed, the mesoglœal folds being complicated and branching. The mesoglœa also forms a thick layer and often contains cell enclosures. The endoderm is very thin.

Œsophagus.—The ectoderm of the œsophagus was not well preserved in our specimens, so that it was not possible to determine its nature or arrangement in a normal condition. There is a well marked groove, and the mesoglœa, which elsewhere is thin, becomes much thickened in this region.

Mesenteries.—The mesenteries present the usual microcnemic arrangement. The imperfect mesenteries are usually well developed. The ectoderm of the œsophagus appears to be reflected in the usual manner, but owing to its bad preservation it is not possible to determine the exact nature of its arrangement. The mesoglœa is well developed, and in each mesentery it contains one or more sinuses or canals which extend throughout the entire height of the mesentery. These sinuses contain numbers of large nematocysts, similar to those found in the ectoderm of the body-wall. The muscles of the mesenteries are not strongly developed. They form almost simple layers.

Gonads.—The sexes are distinct; we found female, but no male gonads, in several of the polyps which we examined. They were all taken from the same colony.

Palythoa kochii, n. sp.

(Pl. LXI., fig. 12; Pl. LXIII., fig. 9.)

Form.—Polyps projecting slightly above the surface of the cœnenchyme; cœnenchyme incrusting, of moderate thickness. Polyps so crowded as to usually have a polygonal contour. The whole surface is incrusted with calcareous particles, etc. Twenty capitular ridges and furrows. Tentacles, 40. Mouth large.

Colour.—Colour of colony, finely speckled buff and cream, each polyp demarcated by a pale border; tentacles similar, but translucent. Disc thin, translucent,

the dark interval cavity shining through; very finely dotted with brown and opaque white. Œsophagus gray, furrowed. Capitular ridges whiter than the rest of the polyp.

Dimensions.—Diameter of polyps about 5 mm.

Locality.—Fringing reefs, Thursday Island, and Mabuiag.

This species is named in honour of our distinguished German colleague, who was the first to discover the precise arrangement of the mesenteries in the Zoantheæ.

Body-wall (Pl. LXIII., fig. 9).—As in the last species the body-wall and cœnenchyme may be regarded as one. The ectoderm, where present, is continuous, and is covered by a thin cuticle. Incrustations, consisting of spicules and grains of sand (the latter being for the most part less coarse than those found in *P. howesii*), form a dense border at the union of the ectoderm with the mesoglœa. They are scattered more sparingly through the deeper parts of the mesoglœa. Lacunæ, canals, and cell islets are found throughout the mesoglœa. Nematocysts are present in both the ectoderm and the lacunæ. Zooxanthellæ are also found in the ectoderm and lacunæ, as well as in the endoderm. The endodermal muscle is well developed. The endoderm forms a uniformly thin layer.

Sphincter muscle.—The mesoglœal sphincter is long and well developed.

Disc and tentacles.—The structure of the disc and tentacles is very similar to that found in *P. howesii.*

Œsophagus—The ectoderm of the œsophagus is not well preserved, but it appears to be thrown into well marked folds. There is a very slight groove, and no appreciable thickening of the mesoglœa in this region.

Mesenteries.—The mesenteries are arranged as in other Brachycneminæ. The imperfect mesenteries are well developed. The reflected ectoderm is not well preserved, but is evidently arranged in the ordinary manner. Sinuses, similar to those found in *P. howesii,* are found in the mesenteries of this species also. The muscular layers are very simple, there being apparently no mesoglœal plaitings.

Gonads.—We found male gonads in several of our specimens, but no female organs were present.

Palythoa cœsia (?), Dana.

(Pl. LXI., fig. 14.)

Palythoa cœsia:

Dana, 1846, Zoophytes, U. S. Exploring Expedition, p. 40. pl. XXX., figs. 3, 3*a*. Milne Edwards, 1857, Hist. Nat. Coralliaires, I., p. 305. Andres, 1884, Le Attinie, p. 332.

Form.—Polyps slightly projecting above the surface of the cœnenchyme when contracted. Cœnenchyme incrusting in small, ovoid, concavo-convex masses of

moderate thickness. Polyps large, not crowded, of rounded contour. The whole surface is incrusted with calcareous particles. About twenty capitular ridges.

Colour.—Grayish-white in spirit specimens.

Dimensions.—Diameter of polyps about 9 mm. The colonies in the specimens before us average about 50 cm. by 40 cm.

Locality.—Reefs, Torres Straits.

We have doubtfully referred this species to *P. cœsia*, which was collected by the United States Exploring Expedition at Fiji. The size and disposition of the polyps are fairly similar in the two forms; but the cœnenchyme of ours is less convex. From the specimen figured (Pl. LXI., fig. 14), it would seem that the colony divides after it has attained a certain size.

Body-wall.—In its anatomy this species is in most respects very similar to that of *P. kochii.* The ectoderm is covered by a thin cuticle, and is continuous. It contains nematocysts and zooxanthellæ. Incrustations are even more numerous than in *P. kochii*, and they penetrate the mesoglœa, which separates the polyps to a greater extent than in that species. They consist of sponge and ascidian spicules, foraminifera, &c., as well of great numbers of grains of sand. Lacunæ of variable size are very numerous in the mesoglœa. In some cases a great number of these lacunæ placed close together form a sort of spongy or vesicular sheath round an individual polyp. Nematocysts are commonly to be met with in the lacunæ. The endoderm is not very well preserved, but it appears to form ridges between the mesenteries, rather than a thin uniform layer as in *P. kochii.* The endodermal muscular layer appears to be well developed.

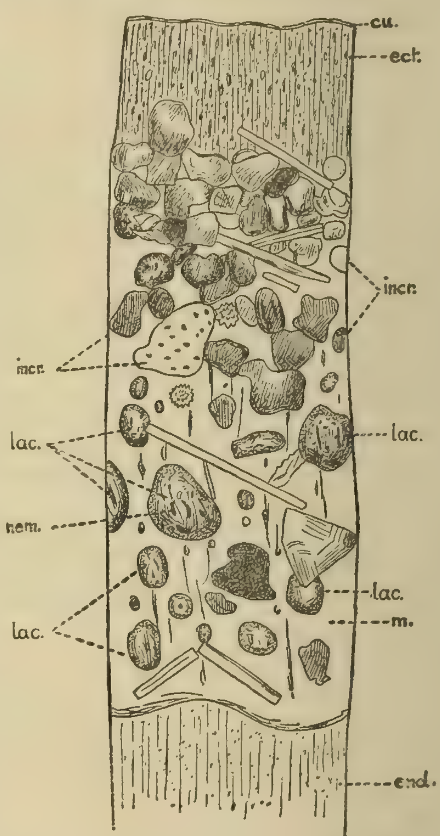


FIG. 2.—*Palythoa cœsia* (?). Transverse section of body-wall.

Sphincter muscle.—The single mesoglœal sphincter is a strong one.

Disc and tentacles.—The disc and tentacles are very similar in structure to those in the last two species, the ectoderm being remarkably thick.

Œsophagus.—Nematocysts are very numerous in the ectoderm of the œsophagus. There is a well marked groove.

Mesenteries.—The arrangement of the mesenteries is brachycnemic. The

mesenteries in other respects seem to be very similar to those of *P. howesii* and *P. kochii.* Well marked sinuses extend through each mesentery from the base to the disc.

Gonads.—We have found no generative organs in this species.

The more irregular disposition of the polyps distinguishes *P. kochii* from *P. howesii*, in which they are arranged more or less in rows. The zigzag appearance due to the partial immersion of the polyps is very characteristic of *P. howesii.* It would require considerable care to distinguish between *P. kochii* and certain other species of the genus. *P. cæsia*, as identified by ourselves, is easily distinguishable from the preceding species on account of the large and non-crowded polyps and the apparently smaller size of the colonies; but we would like to add another warning as to the extreme difficulty in identifying the species of this genus.

SPHENOPUS, Steenstrup, 1856.

Free, solitary, brachycnemic Zoantheæ, with a single, very long, mesoglœal sphincter muscle. The body-wall is incrusted. Cell islets present in the mesoglœa.

Sphenopus arenaceus, Hertwig.

Sphenopus arenaceus:

Hertwig, 1882, Voy. H. M. S. "Challenger," Zoology. Report on the Actiniaria, p. 120, pl. II., fig. 10; pl. XIV., fig. 8. Also, 1886, *ibid.*, Supplement, p. 52.

Hertwig says, in his first report of this species:—"Habitat—Cape York? (the title of the label enclosed with the preparation was nearly entirely destroyed by the rough surface of the animal, and could not be exactly made out), one specimen." In the Supplement he says:—"Habitat—Station 187, Torres Strait, Australia, September 9, 1874; 6 fathoms. Two specimens. . . . In the 'Challenger' material I have found four further examples of the genus Sphenopus; two of these I have determined as *Sphenopus arenaceus*, on account of their rusty red tint, and other two *Sphenopus marsupialis*, in consequence of the earthy-gray colour and the absence of a stalk." The last being a character of his other new species, *S. pedunculatus* (*l. c.* p. 49), from off Panay, Philippine Islands.

This is the only Zoanthean previously recorded from Torres Straits, and it does not occur in our collection. Thanks to the kindness of Professor F. Jeffrey Bell, of the British Museum, we have been able to examine some specimens of *S. marsupialis* which were given to him by Edgar Thurston, Esq., of the Central Museum, Madras, who collected them at Madras.

Hertwig gives no characters by which this species can be distinguished from

S. marsupialis, and we agree with him when he says it is "desirable that with an opportunity of more abundant and fresh material, a renewed study should be undertaken to decide whether the received specific characters are variable, and whether all three species should not be united in the single *Sphenopus marsupialis* (*l. c.* p. 52).

Sub-family. MACROCNEMINÆ.

PARAZOANTHUS, Hadd. & Shackl., 1891.

Macrocnemic Zoantheæ with a diffuse endodermal sphincter muscle. The body-wall is incrusted. The ectoderm is continuous; encircling sinus as well as ectodermal canals; lacunæ and cell-islets in the mesoglœa. Diœcious. Polyps connected by thin cœnenchyme.

This genus is established by us in our second part of the Revision of the British Actiniæ (**1891**, p. 653), to which the reader is referred for fuller details.

TORRES STRAITS SPECIES OF THE GENUS PARAZOANTHUS.

P. dichroicus, n. sp.

P. douglasi, n. sp.

Parazoanthus dichroicus, n. sp.

(Pl. LXI., fig. 15; Pl. LXII., fig. 5.)

Form.—Body short, encrusted with sand and spicules. Capitulum with about eighteen distinct ridges. Cœnenchyme encrusting a specimen of *Plumularia ramsayi*.

Colour.—Body and cœnenchyme, gray; capitulum, pale-yellow.

Dimensions.—2–2·5 mm. in height; 1·25–1·5 mm. in diameter.

Locality—Channel between Mer and Dauar, about 20 fathoms, Jan. 6, 1889. One colony.

This species rendered the alcohol in which it was preserved strongly dichroic—the colours being yellow and violet; we have emphasised this fact in its name, which is also appropriate on account of the gray and yellow colour of the polyps.

Body-wall.—The body-wall is thickly incrusted with foreign bodies, particles of sand, diatoms, ascidian and sponge spicules, &c. (Pl. LXII., fig. 5). These are embedded in the mesoglœa, the ectoderm having for the most part disappeared from

the surface of our specimens. Where present the ectoderm appears to be continuous. It is not penetrated by strands of mesoglœa, nor is there a peripheral layer of mesoglœa. The cuticle is very delicate, and difficult to discern. Beneath the incrustations, and separated from the endoderm by a narrow band of mesoglœa, is an encircling sinus filled with dark brown granular pigment. It is crossed at intervals by strands of mesoglœa. A few branching canals connected with the sinus run outwards through the mesoglœa among the incrustations. Small, round or oval groups of cells, the cell-islets of Erdmann, are scattered throughout the mesoglœa; a very few pigment granules can be seen in some of them. We have not observed any connexion between the sinus or the canals connected with it and these islets. The endoderm is richly pigmented. We have seen no zooxanthellæ.

The capitulum, which in contracted specimens is thrown into deep folds, is also incrusted; but there is a much larger proportion of spicules and relatively fewer sand particles than in the column. The encircling sinus is not continued into the capitulum.

Sphincter muscle.—The endodermal sphincter is supported on slightly branched plaitings of mesoglœa. Near the upper extremity (in contracted specimens) it appears to become embedded in the mesoglœa, a few simple cavities being visible in our sections.

Tentacles.—The ectoderm of the tentacles is thick. The nuclei are scattered diffusely through the outer part, leaving a clear band next the muscular layer. Small nematocysts of the usual description are present. The mesoglœa is thin and almost homogeneous, a very few cell-islets being present. The endoderm contains a few zooxanthellæ, and occasional pigment granules.

Disc.—The ectoderm of the disc is very similar to that of the tentacles, but it contains some pigment. Numerous cell-islets occur in the mesoglœa.

Œsophagus.—The ectoderm of the œsophagus stains more deeply than that of the disc or tentacles. It forms a simple layer, not being thrown into folds. The mesoglœa is fairly thick, especially in the region of the groove, which is well marked.

Mesenteries.—The mesenteries are arranged as in other Macrocneminæ. The imperfect mesenteries are very slightly developed, projecting but little beyond the endoderm. The mesoglœa of the mesenteries is thick, and contains cell-islets, but no canals or sinuses. The longitudinal muscles are well developed and supported on mesoglœal folds. The endoderm resembles that which lines the body-wall.

Gonads.—In one of the specimens cut by us male gonads were found.

Parasites.—Small, oval, deeply pigmented bodies occur in many parts of the body in this species. They are evidently parasites, but we are unable to say anything further about them.

Parazoanthus douglasi, n. sp.

(Pl. LXI., figs. 16–22; Pl. LXII., fig. 6.)

Form.—Body when growing on hydroids often somewhat long and relatively narrow, but when growing on a flat surface, usually short and thick; capitular ridges not well marked; texture gritty; cœnenchyme incrusting.

Colour.—Sand colour.

Dimensions.—Height variable; largest specimens 8–9 mm.; diameter, 2–2·5 mm. The shorter specimens growing on flat surfaces are from 3–5 mm. in height, and 2 mm. in diameter.

Locality.—Albany Pass, Cape York. 10 fathoms. August 29, 1888. Numerous specimens.

[I have named this species in honour of the Hon. John Douglas, K.C.M.G., Government Resident at Thursday Island, Torres Straits, who assisted me as far as was in his power during my stay in Torres Straits.—A. C. H.]

Body-wall.—As in *P. dichroicus*, but little ectoderm remains on the body-wall of our specimens of *P. douglasi*, and that which does remain is continuous and covered by a very delicate cuticle. The incrustations, which penetrate the greater part of the thickness of the mesoglœa, consist chiefly of sponge spicules (some of them being triradiate) with a few grains of sand, foraminifera, &c., amongst them. There is an encircling sinus which contains a few dark granules similar to those which are so abundant in *P. dichroicus*, but it is for the most part almost empty. It is crossed at intervals by the strands of mesoglœa, and is connected with a system of branching canals, which run outwards through the incrustation. Cell-islets, though present, are not at all so numerous as in *P. dichroicus*. The endoderm forms a thin layer of uniform thickness. The muscular layer is feebly developed.

Capitulum.—The incrustations in this region are almost entirely confined to sponge spicules. The ridges, although not externally conspicuous, can be well seen in our transverse sections.

Sphincter muscle.—The spincter muscle is entirely endodermal. The mesoglœal plaitings are regular and simple.

Disc and tentacles—The structure of disc and tentacles is very similar to that of *P. dichroicus*, but there appear to be no enclosures of any kind in the mesoglœa.

Œsophagus.—The ectoderm of the œsophagus is thrown into slight folds. There is a distinct groove, the mesoglœa being much thickened in this region.

Mesenteries.—The arrangement of the mesenteries is brachycnemic. The imperfect mesenteries are even more feebly developed than in *P. dichroicus*, being in many cases hardly discernible. The mesoglœa forms a fairly thick layer,

without enclosures of any kind. It is thrown into very slight plaitings to support the longitudinal muscles, which are not well developed. The parieto-basal muscles are also feebly developed. The endoderm of the mesenteries forms a thin layer similar to that which lines the body-wall.

Gonads.—No gonads were found in our specimens.

Parasites.—We found that many of our specimens of this species were infested by a copepod which deposits its egg in the cœlenteron or cœlenteric canals of the polyp. The capsules are paired, and contain a large number of ova. We have found them in the nauplius stage, as well as in other stages of development. We have two specimens of the copepod, but are unable to say whether these are adult or not. The capsules form distinct swellings of the body-wall of the actinian. This fact leads us to suppose that the copepod remains within the cœlenteric cavities while the capsule is developing, and when the latter is ripe it breaks away from it (Pl. lxi., figs. 19–22).

Small oval parasites, similar to those found in *P. dichroicus*, are also found in *P. macmurrichi.*

The larger size and uniform colouration of *P. douglasi* enable it to be easily distinguished from *P. dichroicus.*

EXPLANATION OF PLATE LXI.

PLATE LXI.

Fig.

1. *Zoanthus coppingeri*, n. sp. (p. 676). Natural size; spirit specimens.

2. *Zoanthus coppingeri*. Drawn from living specimen by A. C. H.

3–4. *Zoanthus jukesii*, n. sp. (p. 678). Sketched from life by A. C. H.

5. *Zoanthus jukesii*. Natural size; spirit specimens.

6. *Zoanthus macgillivrayi*, n. sp. (p. 680). Twice natural size; drawn from spirit specimens by A. C. H.

7. *Isaurus asymmetricus*, n. sp. (p. 684). Natural size; drawn from life by A. C. H.; one specimen is drawn, showing the smooth side.

8. *Isaurus asymmetricus*. Entirely smooth specimen.

9. *Isaurus asymmetricus*. Small variety from Murray Island; natural size; drawn from life by A. C. H.

10. *Gemmaria mutuki*, n. sp. (p. 689). Natural size; spirit specimens.

11. *Gemmaria macmurrichi*, n. sp. (p. 688). Twice natural size; drawn from spirit specimen by A. C. H.

12. *Palythoa kochii*, n. sp. (p. 694). Portion of colony; natural size; spirit specimen.

13. *Palythoa howesii*, n. sp. (p. 693). Portion of colony; natural size; spirit specimen.

14. *Palythoa cæsia*? (Dana) (p. 695). Portion of a bilobed colony; natural size; spirit specimen.

15. *Parazoanthus dichroicus*, n. sp. (p. 698). Natural size; spirit specimen.

16–17. *Parazoanthus douglasi*, n. sp. (p. 700). Natural size; spirit specimens.

18. *Parazoanthus douglasi*. Natural size; portion of a dried colony incrusting stones; dried specimen.

19–22. Copepod Galls on *P. douglasi*—

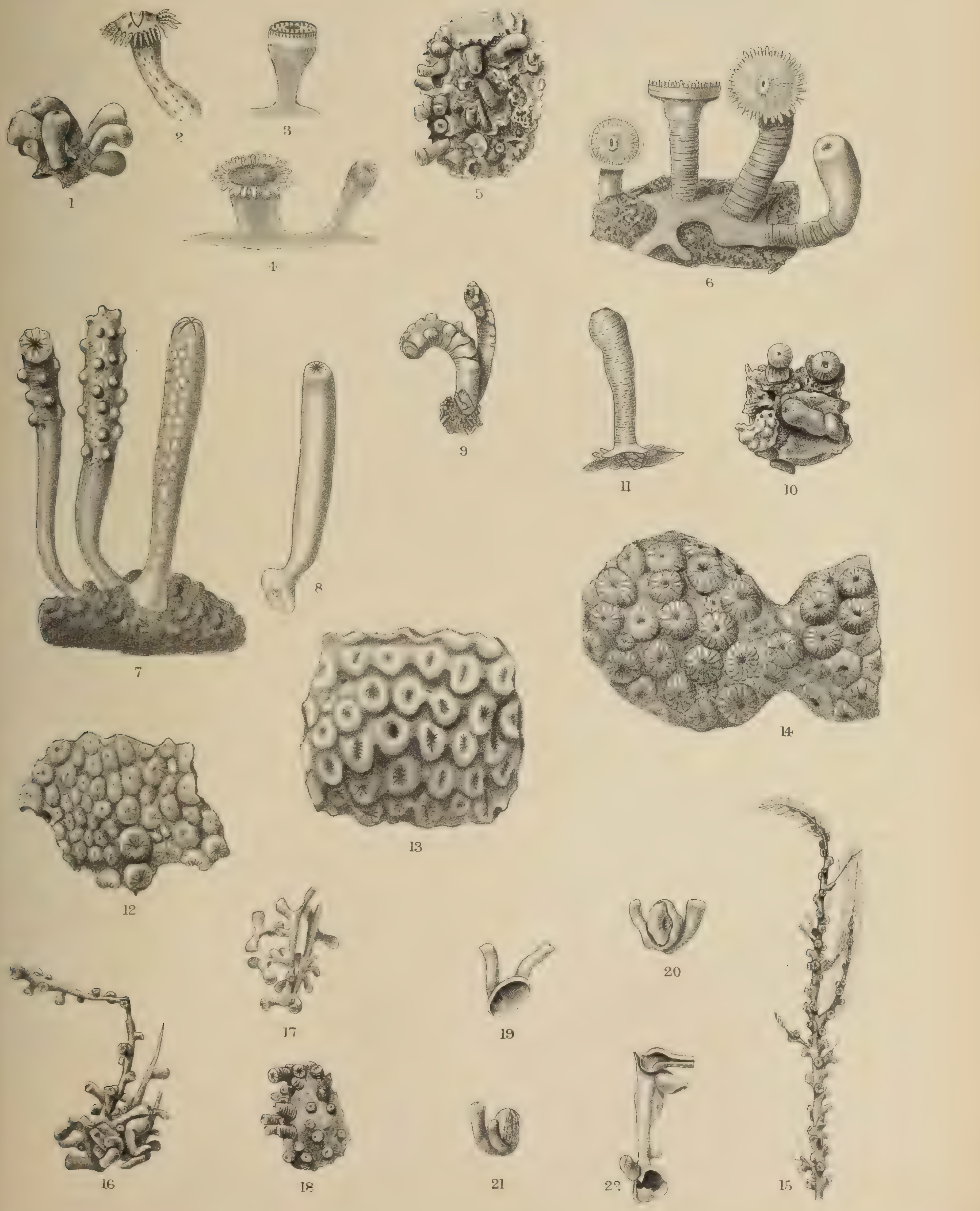
19. Portion of cœnenchyme-wall of gall.

20. Side view of one of the egg-capsules *in situ*.

21. Showing a pair of egg-capsules *in situ*.

22. Two empty galls in base of polyps.

[All the above are in the British Museum, with the exception of fig. 11, of which the single specimen obtained was utilised for anatomical examination.]



M.P. Parker del. et lith

West, Newman imp

EXPLANATION OF PLATE LXII.

PLATE LXII.

LETTERING ADOPTED IN THE FIGURES.

c.i., ...	cell-islets.	*mes. lac.*, . .	mesenterial lacuna.
cu., ...	cuticle.	*mes. sin.*, . .	mesenterial sinus.
ect., ...	ectoderm.	*m. f.*, ...	mesenterial filament.
ect. can., . .	ectodermal canal.	*nem.*, ...	nematocyst.
enc. sin., . .	encircling sinus.	*ov.*, ...	ovum.
end., ...	endoderm.	*par.*, ...	parasite.
incr., ...	incrustation.	*x.*, ...	axial support of incrusting forms.
m., ...	mesoglœa.	*z.*, ...	zooxanthella.

[The axial support in fig. 5 is a Hydroid.]

Fig.

1. *Zoanthus coppingeri*, n. sp. (p. 676). Transverse section through the base of the body-wall, $\frac{2}{A}$.*

2. *Zoanthus jukesii*, n. sp. (p. 678). Transverse section through the base of the body-wall, $\frac{2}{A}$.

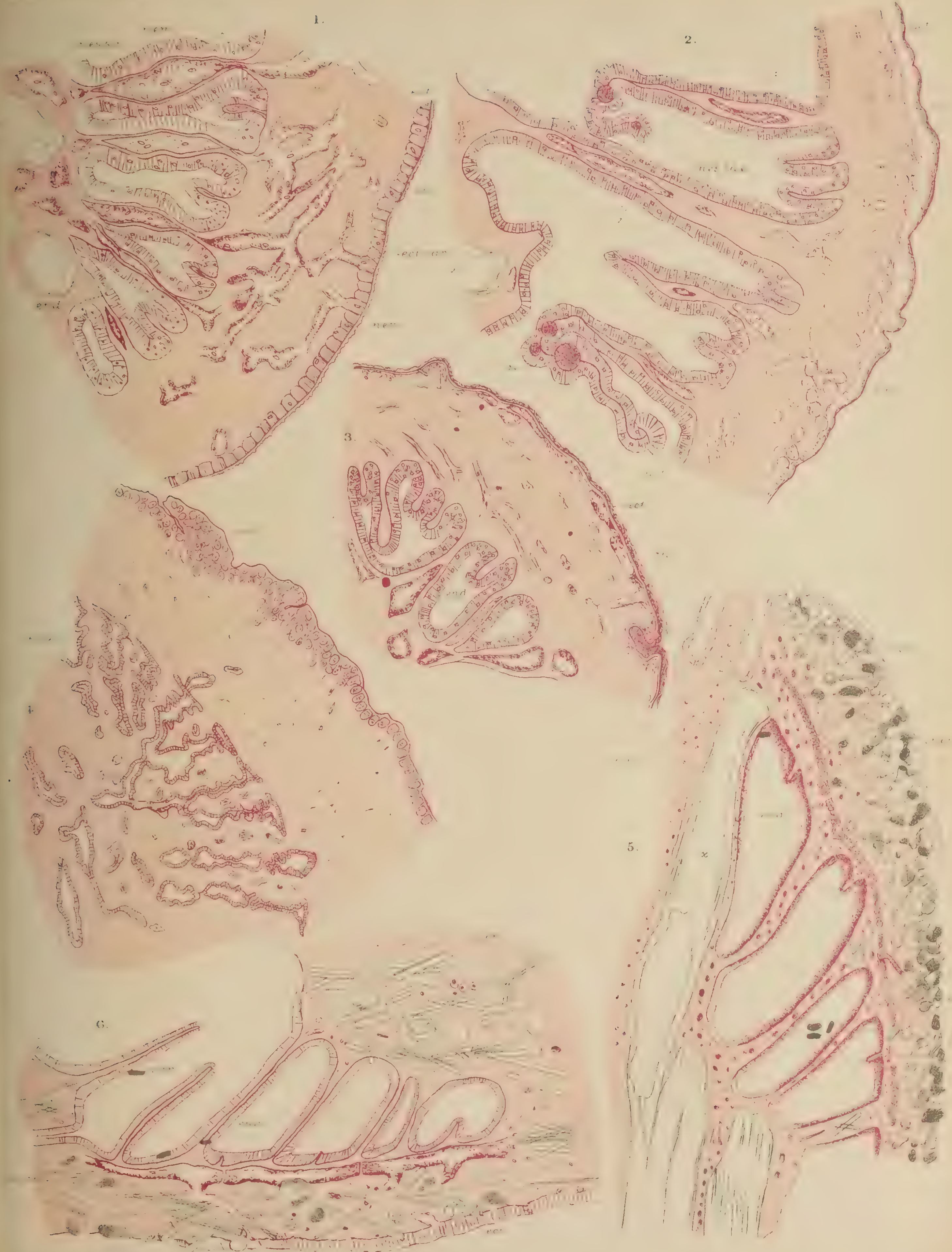
3. *Zoanthus macgillivrayi*, n. sp. (p. 680). Transverse section through the base of the body-wall, $\frac{2}{A}$.

4. *Isaurus asymmetricus*, n. sp. (p. 684). Transverse section through the base of the body-wall, $\frac{4}{a^* \ 10}$.

5. *Parazoanthus dichroicus*, n. sp. (p. 698). Transverse section through the base of the body-wall, $\frac{2}{B}$.

6. *Parazoanthus douglasi*, n. sp. (p. 700). Transverse section through the base of the body-wall, $\frac{2}{B}$.

* These letters of magnification refer in all cases to Zeiss' system.



A M S del. ad nat.
M P Parker chr. lith.

EXPLANATION OF PLATE LXIII.

PLATE LXIII.

LETTERING ADOPTED IN THE FIGURES.

br. cn. mes., . .	brachycnemic mesentery (the sulco-sulcar lateral mesentery).
cœl., ...	cœlenteron.
cu., ...	cuticle.
decal., . . .	lacuna due to the decalcification of an incrustation.
ect., ...	ectoderm.
ect. b., . . .	ectodermal bay.
end., ...	endoderm.
end. can., . .	endodermal canal.
incr., ...	incrustation.
m., ...	mesoglœa.
mes. can., . .	mesenterial canal.
m. sph. m., . .	mesoglœal sphincter muscle.
nem., ...	nematocyst.
œs., ...	œsophagus.
s. d., . . .	sulcar directive mesenteries.
s. gr., . . .	sulcar groove.
sl. d., . . .	sulcular directive mesenteries.
vert. can., . .	vertical canal.
z., ...	zooxanthella.

Fig.

1. *Zoanthus jukesii*, n. sp. (p. 678). Transverse section through the œsophageal region of the column, $\frac{4}{a^*\ 10}$.

2. *Zoanthus macgillivrayi*, n. sp. (p. 680). Transverse section through the lower portion of the column, $\frac{3}{a^*\ 8}$.

3. *Isaurus tuberculatus* (Gray), (p. 617 of British Zoantheæ). Section through an ectodermal bay, $\frac{2}{B}$.

4. *Isaurus asymmetricus*, n. sp. (p. 684). Vertical section through a sphincter muscle, $\frac{2}{a^*\ 10}$.

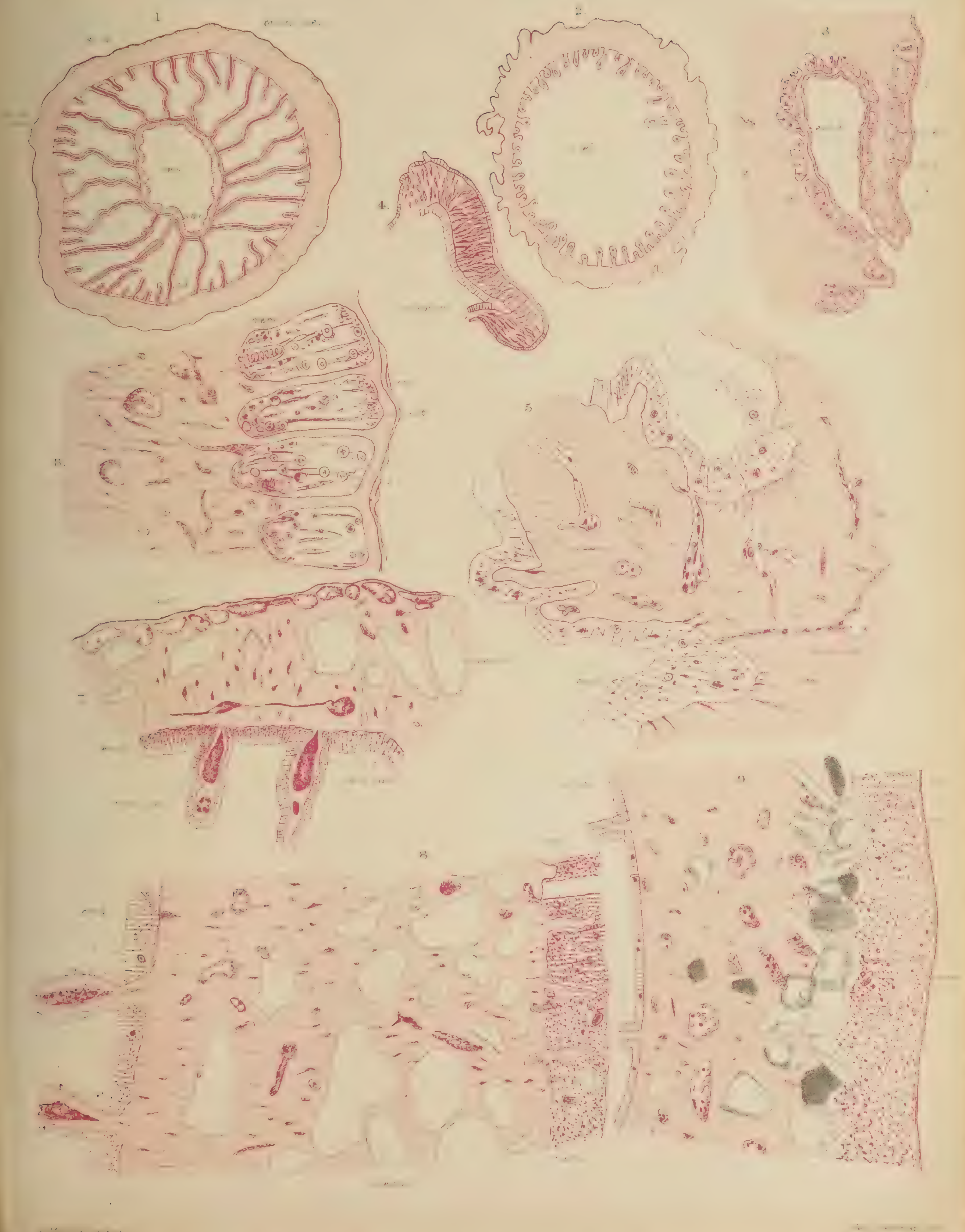
5. *Isaurus asymmetricus*. Transverse section through a portion of the centre of the base of the column, $\frac{2}{D}$.

6. *Isaurus asymmetricus*. Transverse section through the periphery of the body-wall, $\frac{2}{D}$.

7. *Gemmaria macmurrichi*, n. sp. (p. 688). Transverse section through the body-wall (decalcified), $\frac{2}{B}$.

8. *Palythoa howesii*, n. sp. (p. 693). Transverse section through the body-wall (decalcified), $\frac{2}{B}$.

9. *Palythoa kochii*, n. sp. (p. 694). Transverse section through the body-wall, $\frac{2}{B}$.



EXPLANATION OF PLATE LXIV.

PLATE LXIV.

LETTERING ADOPTED IN THE FIGURES.

cu.,	cuticle.
d. m. sph.,	double mesoglœal sphincter muscle.
ect.,	ectoderm.
ect. can.,	ectodermal canal.
end.,	endoderm.
end. b.,	endodermal bay.
end. canl.,	endodermal canaliculus.
end. m.,	endodermal circular muscle of tentacle.
f. b.,	food-ball (?).
l. m.,	longitudinal muscle.
m.,	mesoglœa.
mes. can.,	mesenterial canal.
mes. sin.,	mesenterial sinus.
m. f.,	mesenterial filament.
n. c.,	nerve-cell.
nem.,	nematocyst.
œs.,	œsophagus.
ov.,	ovum.
p. b. m.,	parieto-basilar muscle.
r. ect.,	reflected ectoderm.
sp.	sperm-cell (testis).
t.,	tentacle.
z.,	zooxanthella.

Fig.

1. *Zoanthus coppingeri*, n. sp. (p. 676). Transverse section through the body-wall, $\frac{2}{D}$.

2. *Zoanthus coppingeri*. Transverse section through the wall of a tentacle, $\frac{2}{D}$.

3. *Zoanthus coppingeri*. Verticle section through the half of a polyp; slightly diagrammatic; the ectoderm, ectodermal canals, mesoglœa, mesenteric canals, gonads, and sphincter muscle are coloured red; the endoderm and the endodermal canals are coloured blue, $\frac{3}{a^* \ 6}$.

4. *Zoanthus coppingeri*. Transverse section through a perfect mesentery, $\frac{2}{B}$.

5. *Zoanthus macgillivrayi*, n. sp. (p. 680). Vertical section through a portion of a polyp, $\frac{3}{a^* \ 8}$.

6. *Zoanthus macgillivrayi*. Transverse section through part of a perfect mesentery, with reflected ectoderm, $\frac{2}{C}$.

7. *Zoanthus macgillivrayi*. Transverse section through a perfect mesentery, showing the upper portion of the mesenterial filament, $\frac{2}{C}$.

8. *Zoanthus macgillivrayi*. Transverse section through a perfect mesentery, showing the lower portion of the mesenterial filament, $\frac{2}{C}$.

9. *Isaurus asymmetricus*, n. sp. (p. 684). Transverse section through two perfect and one imperfect mesenteries in the œsophageal region; also showing an endodermal bay, $\frac{2}{A}$.

XIV.

ON THE FOSSIL FISH-REMAINS OF THE COAL MEASURES OF THE BRITISH ISLANDS. PART I.—PLEURACANTHIDÆ. By JAMES W. DAVIS, F.G.S., F.L.S., F.S.A., &c. Plates LXV. to LXXIII.

[Read January 20, 1892.]

[communicated by the honorary secretaries.]

I.—INTRODUCTION.

It is proposed in this work to describe, and where desirable to figure, the fossil fishes whose remains have been discovered in the several coal fields of Great Britain. For the purposes of this work the Coal Measures will include all the strata between the uppermost bed of Millstone Grit at their base, and the Permian Rocks which immediately overlie them. The subject is a large one, and for convenience of publication, as well as in the preparation and arrangement of the material, it appears advisable to divide it into a series of monographs, commencing with the Elasmobranchii, and of this sub-class the Pleuracanthidæ will first receive attention. Except incidentally, the stratigraphical distribution of the fish-remains will be considered later, when all the available material shall have been examined and recorded.

I cannot neglect the present opportunity to express my indebtedness to those gentlemen having the charge of public or private museums, for their uniform courtesy and kindness in permitting me to visit their collections, and still more for the readiness with which such parts of the collections as were necessary for comparison or identification have been placed at my disposal. Amongst such instances I may mention the Natural History Department of the British Museum, Cromwell-road, London; the Museum of the Natural History Society of Northumberland, Durham, and Newcastle-on-Tyne; the Manchester Museum at the Owens College; the Woodwardian Museum at Cambridge; the Museums of the Philosophical Societies at Leeds, Halifax, and York; the Hunterian Museum at Glasgow, and the Museums of Science and Art at Edinburgh and Dublin.

Amongst the owners of private collections I am greatly indebted to my friends and co-workers, James Thomson, Esq., of Glasgow; Dr. J. R. S. Hunter, of Carluke, and R. Dunlop, Esq., of Airdrie, in Scotland; George Wild, Esq., of Bardsley, and James Nield, Esq., of Oldham, in Lancashire; Professor Louis C. Miall, of the Yorkshire College, and T. W. Embleton, Esq., of Methley, in Yorkshire; to William Dinning, Esq., of Newcastle, an able palæontologist, to whose manipulative skill science is indebted for some of the most beautiful examples figured in the present monograph, I owe many thanks. No worker in this branch of palæichthyology can afford to do without the assistance of John Ward, Esq., of Longton, in Staffordshire; his great collection, unique in many respects, and the result of many years of patient investigation, is invaluable; and to this collection, and the practical knowledge possessed by Mr. Ward, willingly placed at my disposal, I am under deep obligations. And lastly, to A. Smith Woodward, Esq., whose fellowship is very dear to me, I am indebted for many helpful courtesies and kindnesses, which may perhaps be more easily understood than expressed.

II.—CLASSIFICATION AND DESCRIPTION.

Class.—PISCES.

Sub-Class I.—ELASMOBRANCHII.

Order I.—Ichthyotomi (E. D. Cope and A. Smith Woodward).

Syn.—Xenacanthidæ, H. B. Geinitz, C. F. Lütken, Anton Fritsch; Pterygacanthidæ, Ch. Brongniart.

Endoskeletal cartilage permeated throughout with granular calcifications; notochord rarely or never constricted; calcifications of the sheath arrested at the most primitive rhachitomous stage, except in the caudal region. Neural and hæmal arches and spines long and slender; with or without intercalary cartilages. Pectoral fins with long segmented axis (archipterygium).

Family.—**PLEURACANTHIDÆ.** A. Smith Woodward, Ch. Brongniart.

Syn.—Xenacanthidæ, Anton Fritsch.

Body slender, but slightly depressed; mouth terminal; tail diphycercal; dorsal fin elongate, low, continuous along the back from a point shortly behind the head; slender interneural cartilages more numerous than the neural spines. Pectoral fin with biserial arrangement of cartilaginous rays.

Genus **Pleuracanthus**, Agassiz. "Rech. sur les Poissons Fossiles," 1837, vol. iii., p. 66.

Diplodus, ... Agassiz, L., 1843. "Poiss. Foss.," vol. iii. p. 204.
Orthacanthus, . . . Agassiz, L., 1843, *tom. cit.*, vol. iii., pp. 177, 330, pl. xlv., figs. 7–9.
Xenacanthus, . . . Beyrich, E., 1848. "Bericht K. Preuss. Akad. der Wissenschaften," p. 24.
Triodus, ... Jordan, 1849. "Neues Jahrb.," p. 843.
Compsacanthus, . . Newberry, J. S., 1856. "Proc. Acad. Nat. Sci. Philadelphia," p. 100.
Dittodus, ... Owen, R., 1867. "Trans. Odont. Soc.," vol. v., p. 325.
Aganodus, . . . Owen, R., 1867, *tom. cit.*, p. 359.
Ochlodus, . . . Owen, R., 1867, *tom. cit.*, p. 346.
Pternodus, . . . Owen, R., 1867, *tom. cit.*, p. 363.
Trinacodus, . . . St. John and Worthen, 1875. "Palæont. Illinois," vol. vi., p. 289.
Lophacanthus, . . . Stock, T., 1880. "Ann. Mag. Nat. Hist." series 5, vol. v., p. 217.
Didymodus, . . . Cope, E. D., 1883. "Proc. Acad. Nat. Sci. Philadelphia," p. 108.

Body comparatively elongated; skin destitute of shagreen; head large and depressed; cranium consisting of segments, more or less ossified, separated by sutures; mouth terminal, widely extended; jaws bearing numerous teeth (*Diplodus*), arranged as in the Selachii; notochord persistent; neural and hæmal arches ossified, the ossification presenting a mosaic appearance due to granular calcifications; seven gill arches (Fritsch) the seventh arch without gills; gill rakers present (*Stemmatodus*); head surmounted by a spine, straight or slightly curved; opening of internal cavity of spine terminal; along some part of the surface extends two rows of denticles; these may be widely separated and lateral (*Pleuracanthus*); they may be in close proximity along the posterior surface (*Orthacanthus*) or the two rows may occupy any intermediate position between the two. Attached to the spine is a small cephalic fin; dorsal fin commencing immediately behind the head extends to the base of the caudal; the fine rays supported by interspinous and surapophysial bones more numerous than the neural spines; tail diphycercal with a pointed extremity; pectoral fins supported by a long articulated axis (archipterygium) with a bi-serial arrangement of semi-osseous

lateral cartilages; ventral fins with an articulated axis supported by a pair of triangular pelvic cartilages and lateral cartilages on external surface; in the males the fins are provided with claspers; two anal fins placed one behind the other, attached to the hæmapophyses by a series of intermediate ossicles.

The genus *Pleuracanthus* was instituted by Agassiz* and embraced a fish spine from the coal shales of Dudley; its surface was rounded and at the same time depressed and armed on each side by a range of denticles arched towards the base. The spine was considered to belong to an undescribed genus of the family of the Rays. One species was described, *P. lævissimus*, Ag.† A second species was referred to six years later, but not described, viz. *P. planus*, Ag., in the same volume, p. 177. This was from the Coal Measures in the neighbourhood of Leeds. The type specimen is in the Egerton collection at the Natural History Museum, London, and is now determined as the spine of a young example of *P. lævissimus*. Prof. Agassiz refers on the same page‡ to another spine, *Orthacanthus cylindricus*, Ag., from the Coal Measures at Leeds; and again when considering the defences of the Rays, *O. cylindricus* is described as a straight spine of cylindrical form armed with two rows of sharp denticles on the posterior surface. The spine is stated to be from the Coal Measures in the neighbourhood of Manchester. The near relationship of *Orthacanthus* with the genus *Pleuracanthus* is recognized.

In 1841, Mr. E. W. Binney first noticed certain teeth from the Lancashire coal field to which he appended the name *Diplodus gibbosus.*§ The specimen was figured but without description; the latter was given by Agassiz,|| and specimens were described from the Coal Measures of Staffordshire and of Carluke in Scotland.

Dr. Goldfuss¶ described a specimen ascribed to the genus *Orthacanthus* from the lower Permian Sandstones of Ruppersdorf in Bohemia exhibiting the upper surface of the head and a large portion of the body. The mouth was large and terminal with numerous rows of small three-pronged teeth. The spine, still in position, was embedded in a cartilaginous mass immediately behind the head. It was round, with a median ridge on the dorsal aspect; and on each side the ridge, separated by a narrow groove, was a row of denticles. The spine was on front of the first dorsal fin, considered subsequently by C. Brongniart,** as a cephalic fin. The second long dorsal fin was without spine. The pectoral arch is described as being built up, on either side of an internal bone, composed

* Rech. sur les poissons fossiles, vol. iii., p. 166. 1837. † *Op. cit.*, pl. XLV., figs. 4 and 5.

‡ *Op. cit.*, p. 177 and p. 330, pl. XLV., figs. 7–9. 1843.

§ Trans. Manchester Geol. Soc., vol. i., p. 169, pl. V., figs. 17–18.

|| *Op. cit.*, p. 204, pl. XXII. *b*, figs. 1–5.

¶ Beiträge zur vorweltlichen Fauna des Steinkohlengebirges, p. 23, pl. V., figs. 9–11, 1847, Bonn.

** Bull. Soc. de l'Industrie Minérale, ser. 3, vol. ii., 1888.

of a single piece, which towards its hinder part is bent on its outer edge in the form of a knee. This edge supports a number of fin-rays, the anterior ones fine and short, those behind longer and thicker. From the knee-shaped angle springs a strong distinctly jointed ray (axis of archipterygium). To this are attached, on its outer margin, seventeen thick strong rays; and on its inner margin a number of smaller and closer rays. In the Ruppersdorf specimen it is not clear by what means the knee-shaped bone was attached at its proximal extremity. The ventral fins are similarly connected to those of the pectoral. A broad, short geniculate bone was suspended from the vertebral column, and to this was attached an articulated primary ray as in the pectoral fin; but they differ from the pectorals in having lateral rays only on the outer margin.

M. Beyrich described and discussed, a year later, the relationship of a fish * similar in all essential respects to the *Orthacanthus* described by Goldfuss, except that in this specimen the spine was flattened before and behind, and had on each side rows of sharp, short, hook-shaped, backward-pointing teeth. To this fish the new generic name *Xenacanthus* was given, and the opinion expressed that *Orthacanthus Dechenii* of Goldfuss must be given up in its favour; and further that though the spine is evidently the same genus as the *Pleuracanthus* of Agassiz, which has priority, the latter is only known as the name of a spine, and consequently must give way to *Xenacanthus*, which represents a more or less perfect fish.

Sir Philip de Malpas Grey Egerton, at the meeting of the British Association at Glasgow, in the year 1855, drew attention to the generic identity of the spines called *Pleuracanthus* and *Xenacanthus*, and the teeth named *Diplodus;* and in 1857,† he published a paper in the "Annals and Magazine of Natural History," in which the claim of *Pleuracanthus* to priority over the other names is enforced, and consequently it should stand as the name of the genus.

It was suggested by Prof. H. B. Geinitz that the ventral plates might have been a sucker, and the fish allied to the genus *Cyclopterus*.‡

In 1867, Prof. D. Rudolph Kner published a memoir, "Ueber Orthacanthus Decheni. Goldf. oder Xenacanthus Decheni Beyr."§ Specimens located in the museums of Dresden, Berlin, Breslau, Vienna, and others are described in detail. Kner argues that the two genera named, along with *Diplodus* teeth, are identical, as was stated by Goldfuss twenty years previously. The fish is described as having a large head, somewhat flat, with a large rounded terminal mouth. The pectoral fins were broadly expanded and the body tapered towards the tail. The

* Bericht der Königl. Preussischen Akademie der Wissenschaften, p. 24, 1848.

† Ann. Mag. Nat. Hist., ser. 2, vol. xx., p. 423.

‡ Der Dyas, p. 23, pl. xxIII., fig. 1, 1861.

§ Sitzungsberichte Kaiser. Akad. Wiss. Wien, vol. lv., pt. I., p. 540, pls. I.-x. 1867.

body may have been covered with shagreen, but in the specimens available for observation the skin was without scales or other protection. The spine was apparently one-fourth to one-fifth of the entire length of the fish; it was implanted in the occipital cartilage without articulation. The vertebral column was notochordal, more or less encircled by the bony extremities of the apophyses; ribs, short and rudimentary, were present, with the articulating extremity broad, and the opposite one pointed. Immediately behind the spine there originated a dorsal fin, which extended along the back to the caudal extremity. In addition to the fin rays and the spinous processes attached to the vertebral column, there were two series of interspinous bones. This arrangement extended to a short distance beyond the ventral fin. The smaller interspinous bones, surapophyses of Fritsch, next to the neurapophyses, then disappear, and the longer interspinous bones continue nearly to the caudal extremity of the body. A fin also extended along the ventral surface of the body, and joining the dorsal one formed a single-lobed tail.

Dr. Kner describes four or five gill arches, furnished with a few long teeth. The skull was of so soft and cartilaginous a nature that the orbits are obliterated, and no evidence is afforded of any segmentation of the covering of the skull. The constituents of the cranium and the jaws were recognized as consisting of cartilage filled with closely approximating ossicular centres. This enamel-like arrangement was compared by Beyrich to a species of mosaic. The upper jaws are stated to consist of maxillary bones, with pre-maxillaries attached, both provided with teeth.

The organs attached to the ventral fins, considered by Dr. Geinitz to have been suckers, were described by Dr. Kner as hooking organs similar to the claspers of sharks found at the present time, and this opinion he enforced by the observation that some of the fishes possessed these appendages and others did not; those possessing them being the male fishes, and those devoid of them being females.

Messrs. Hancock and Atthey found the teeth of *Diplodus*, associated with large patches of thick granular substance resembling shagreen, in the Coal Measures of Newsham and Cramlington, in Northumberland. This association led them to write:*—"There can be little doubt that these shagreen-like patches are the remains of the skin of some large fish, and that the Diplodi are dermal tubercles in connexion with it, and analogous to the spinous tubercles of the Rays. At the same time it must be admitted that it is possible enough that the larger specimens may have clothed the lips or jaws with a spinous pavement resembling in arrangement the oral armature of the Rays or Cestracions." The authors describe the great variation in size and form of the so-called dermal tubercles, and recognize that the *D. minutus*, Ag., belongs to the same species as *D. gibbosus*. It is also

* Nat. Hist. Trans. Northumberland and Durham, vol. iii., p. 111. 1879.

pointed out that the genera *Dittodus*, *Aganodus*, *Pternodus*, and *Ochlodus*, described by Prof. Owen, are all referable to *Diplodus*, and had been established on varying examples, more or less fragmentary, of the teeth of that genus.*

A Paper was published by the writer in 1880,§ on the genus *Pleuracanthus*, Agass., in which several new forms of spines are described, principally derived from the cannel coal at Tingley, near Leeds, but also from the Staffordshire coal field and Lower Coal Measures of the West Riding of Yorkshire. These spines exhibited a number of intermediate forms between *Pleuracanthus lævissimus*, Ag., and *Orthacanthus cylindricus*, Ag. The latter possesses two rows of denticles, which are situated comparatively close together on the median posterior surface, whilst the former has also two rows of denticles on the sides of the spine and as widely separated as it is possible that they could be. The examples described in the Paper "prove that the difference in the relative position of the two rows of denticles must either be of small generic importance or that many new genera will have to be formed for their accommodation. Almost every intermediate form between the two is now known; the denticles extend at every angle between the sides and back of the spine." After careful consideration the opinion is enunciated that the several spines were borne by fishes having characters of a single generic type, and that they should consequently be included, under different specific determinations, in the genus *Pleuracanthus*. The *Diplodus* teeth have hitherto been found indeterminately associated with the spines of *Pleuracanthus*, *Xenacanthus*, and *Orthacanthus*, and afford additional evidence of their generic identity.

Professor E. D. Cope‡ has recorded the occurrence of more or less complete crania from the Permian beds of Texas. The specimens also include jaws and numerous teeth. The teeth are indistinguishable from *Diplodus gibbosus*, Ag., and *Diplodus compressus*, Newb. The latter is provisionally referred to a distinct genus, and styled *Didymodus*. Twelve more or less well-preserved crania were examined, one of which exhibited the jaws with teeth and a part of the cranium. The skull formed a continuous piece with distinct segmentation; it was elongated posteriorly and abbreviated anteriorly, the orbit occupying a position on the anterior third of the cranium with well-defined pre-orbital and post-orbital processes. The top of the muzzle is described as being "excavated by a fontanelle which does not extend posterior to a line connecting the pre-orbital processes." The occipital elements form a wedge-shaped body divided medially by a suture with the apex forward. A second triangular bone is the parietal; its apex is concealed beneath the free extremity of the bone preceding it. On each side, between the occipital and parietal elements are bones which Professor Cope

* Trans. Odont. Soc., vol. v., 1867.

† Quart. Journ. Geol. Soc., vol. xxxvi., p. 321, pl. xii.

‡ Proc. American Phil. Soc., vol. xxi., p. 572, with plate. 1884.

considers may be the intercalare or pterotic. The element in front of the parietal is the cartilaginous representative of the frontal, which terminates posteriorly in two free processes. There are also "distinct paired membrane bones which appear to represent the frontals in *Ceratodus*"; each is a flat, subcrescentic supra-orbital plate, which has a concave superciliary border. It is separated by a considerable interval from its fellow on the opposite side. A fossa on its anterior extremity is supposed to represent the anterior nostril.

The occipital bone includes ex-occipital and basi-occipital elements combined. There is a prominent cup-shaped occipital condyle. The occipital extends only a short distance on the inferior surface, and is attached directly and without imbrication, to a continuous axial element which it is suggested is a combination of the sphenoid and pre-sphenoid bones. The upper jaw, consisting of palatine and pterygoid elements without division, was apparently articulated with the post-orbital process of the cranium. The posterior border of the palato-pterygoid forms a prominent rim descending to the mandible and forming a regular ginglymus, the mandible bearing the cotylus. The mandible is robust; inferior edge thin and incurving anteriorly. The superior border is regular, only rising a little in the coronoid region corresponding with a concavity in the pterygoid region. A portion of a hyo-mandibular bone is exposed.

These remarkable specimens constitute the first recorded discovery of the skulls of *Pleuracanthus*, showing that they were divided by sutures into segments, and this Prof. Cope considered was a sufficient reason for the institution of a new order of the Elasmobranchii, which he names the Ichthyotomi.

A very interesting series of specimens, between twenty and thirty in number, have been found by M. Fayol in the Coal Measures of Commentry, Allier, in France. These were forwarded to M. Charles Brongniart, of the Museum of Natural History, Paris, and have been described and figured as *Pleuracanthus Gaudryi*, Brong.* They vary in length between 0·5 and 1·0 m., and the head occupies about one-fifth the length of the fish. It is not possible, in any of the specimens, to distinguish the pieces composing the head. The jaws are rounded in front and furnished with small teeth along their borders. On one specimen four grooves were distinguishable, probably representing the branchial arches. The spine is straight, pointed, and on the upper part on each side is a row of denticles, recurved towards the base of the spine, which most nearly approaches *P. Frosardi*, Gaudry, and *P. pulchellus*, Davis. "Derrière l'aiquillon céphalique se dressent de petits rayons réunis à lui par une membrane, formant ainsi une nageoire que nous appellerons *céphalique*." This fin is stated to be similar to that

* "Études sur le terrain houiller de Commentry," Bull. Soc. de l'Industrie Minérale, ser. 3, tome II. 4ième Livr. 1888, pls. I.–VI., woodcuts 1–15.

of Cestracion, except that it is in a more advanced position. The dorsal fin extends the whole length of the back to the base of the caudal, equal to three-fifths the entire length of the fish. The dorsal fin, as previously shown by Kner* in specimens from Klein-Neundorf, is supported by a complicated series of rays. The bony neurapophyses are broad at the base, forked above; to each branch of the fork is attached a short ray, the surapophysial, to which is attached the interspinous ray supporting the fin-ray. The caudal fin encircles the posterior extremity of the body. Its upper lobe is supported by a series of rays similar to those of the dorsal fin, except that the surapophyses are absent; and nearer the extremity the interspinous bones also disappear. The hæmapophyses are more robust and longer than the neurapophyses, but have no rays attached: the first five or six hæmal arches are composed of two parts, united at their base and encircling the notochord. Further back they diminish in length and lose this character. The scapular and clavicular elements of the shoulder girdle are cemented into one piece, and their junction forms the point of attachment of the pectoral fin. The central support of the fin consists of a jointed pterygium, the elements composing it gradually diminishing in size, the last being long and filiform. From the external margin of this axis spring the fin-rays, varying in length, and articulated. On the internal margin there is a smaller number of rays, not articulated. M. Charles Brongniart considers the pectoral fin of *Pleuracanthus* to exhibit characteristics intermediate between the biserial articulated pterygium of *Ceratodus* and the pectoral fin of *Acanthias vulgaris*. The pelvic arch has a general resemblance to the pectoral, but it is smaller. Each fin is attached to a moiety of the arch, similar in form and comparable in parts to the scapula and clavicle of the pectoral arch. The median axis is composed of cylindrical cartilaginous elements placed end to end, but diminishing little, if any, in size, and the fin-rays are attached only to the external margin. The axis, instead of being straight, as in the pectoral fin, is curved and forms the arc of a circle. To the extremity of each axis is attached a piece which can only be regarded as an appendix to the genital organs, similar to the claspers in the sharks, rays, and chimera. These are found only on the male fishes. In the female the pelvic fins are feebler, and the median axis terminates within the membrane of the fin.

There are two anal fins which have remarkable peculiarities. They are lobate, rounded, contracted at the base, enlarged in the middle, and again contracted towards the extremity. Both fins are similarly constructed. The hæmapophyses to which they are attached are shorter and more inclined than those of the caudal region; they are truncated instead of pointed, and three

* Sitzungsberichte Kaiser. Akad. Wiss. Wien, vol. lv., pt. I., p. 540, pls. I.–X. 1867.

in number. The first and second have attached to them interspinous bones and fin-rays. The third is larger, broad at the two extremities, slightly curved, and towards the middle, on the concave side, is a sort of apophyse, to which is attached an interspinous ray and a fin-ray; its extremity supports a shorter and broader ossicle. The latter affords attachment to three elements—first, a long and pointed ray, extending backwards, and two ossicles, of which the posterior one supports two short ossicles and fin-rays, and the anterior one one ossicle and one fin-ray. "Ces nageoires anales présentent donc une structure très complexe et rappellent par leur disposition de véritables membres."*

Mr. A. Smith Woodward has pointed out† that the teeth of *Didymodus* are generically indistinguishable from those of *Diplodus*, and he has included the two in the genus *Pleuracanthus*. This author is also convinced that the presence of membrane bones‡ in the skulls of the Texas specimens is more than problematical, and founded on a misconception. Reporting on a recent visit to Professor Cope's collection of fish and other fossil remains at Philadelphia, Mr. Woodward says§ the skulls of the Ichthyotomous Elasmobranch "Didymodus" certainly exhibit with distinctness the extraordinary fissuring of the chondro-cranium, though in the strict sense of the term it is scarcely accurate to name the segmented parts "bones."

During the years 1889 and 1890 Dr. Anton Fritsch of Prague published two parts of his important work on the gas coal of Bohemia,|| which are almost entirely occupied with the genus *Pleuracanthus*, as now defined. Dr. Fritsch prefers to regard *Pleuracanthus*, *Xenacanthus*, and *Orthacanthus* as distinct and independent genera, and bases his diagnosis upon the teeth, spines, and denticular appendages of the gill arches, taken in conjunction with the construction of the archipterygium and fin-rays of the pectoral fins. Four species of *Orthacanthus* are described, viz. *O. Bohemicus*, Fr.; *O. Kounoviensis*, Fr.; *O. pinguis*, Fr.; *O. plicatus*, Fr.; and a fifth, *O. Senkenbergianus*, Fr., is from Lebach. The remains are of a more or less fragmentary character. The remains of *Pleuracanthus* and *Xenacanthus* are much more perfect, and the study of them has enabled Dr. Fritsch to add considerably to our knowledge of the Pleuracanths. Only one species of *Xenacanthus* is recognized, the type *X. Decheni*, Goldf., whilst there are four species of *Pleuracanthus* from the Bohemian formations described, they are, *P. ovalis*, Fr.; *P. Œlbergensis*, Fr.; *P. carinatus*, Fr.; and *P. parallelus*, Fr. The denticles on the spines of both genera are lateral, but the cavity is said to be smaller in *Pleuracanthus* than in *Xenacanthus*, and there is in the former an external median groove on the posterior

* *Op. cit.*, p. 23.

† Cat. Foss. Fishes, Brit. Mus., pt. I., p. 3. 1889.

‡ *Op. cit.*, Introd., p. xxiii.

§ Geol. Mag. Dec., III., vol. vii. Sep., 1890.

|| Fauna der Gaskohle und der Kalksteine der Permformation Böhmens, Band II., Heft 4, pp. 98–112, pls. LXXXI.–XC., 1889; and Band III., Heft 1, pp. 1–48, pls. XCI.–CII., 1890.

surface. The pectoral fins do not differ greatly in *Orthacanthus* and *Pleuracanthus*, but in *Xenacanthus* the fin is shorter proportionately to the others, and there are dermal fin-rays, which the others do not possess. The skull is described as consisting of a continuous cartilage, without segmentation or membrane ossification, and there are seven gill-arches; the shoulder girdle is more or less similar to a gill-arch. The spine is attached to the posterior portion of the cranium and is not attached to a fin. The cartilaginous skeleton exhibits a granular calcification. The vertebral column is notochordal, the neural and hæmal arches are largely ossified, and in two genera there are intercalary cartilages. The pelvic fins are provided with claspers in mature male fishes. The form and structure of the anal fins is fully elucidated. The work is illustrated with numerous figures, in addition to the plates, mostly taken from galvanoplastic models of the original specimens.

Dr. Fritsch sums up the result of his work on this family in the following terms:—Die Haut enthielt keine Schuppen. Das Knorpelskelet ist in allen seinen Theilen mit Kalkprismen durchsetzt. Der Schädel ist eine einheitliche Kapsel ohne alle Deck-Knochen. Der Nackenstachel sitzt auf einer Papille der Schädelkapsel und ist mit keiner Flosse in Verbindung. Die Wirbelsäule ist notochord, mit verkalktem centralen Faserstrang, Wirbelkörper kommen nicht zur Entwickelung. Das System der oberen Wirbelbögen ist stark entwickelt und bei zwei Gattungen kommen Intercalaria vor. Es sind sieben Kiemenbögen vorhanden. Der Schultergürtel ist mit einem Kiemenbogen vergleichbar. Die paarigen Flossen entwickelten sich aus einer Reihe ursprünglich neben einander liegenden Strahlen. Die Glieder des sogenannten Hauptstrahles entstanden theils durch Verdickung der Glieder eines Strahles, theils durch Verschmelzung mehrerer Nebenstrahlen. Ein Becken ist nicht vorhanden. Das Basalstück der Bauchflosse entstand durch Verschmelzung von Flossenstrahlen. Die Pterygopodien der alten Männchen sind ähnlich gebaut wie die der jetzigen Haie und auch bei alten Weibchen kamen ähnliche Hilfsorgane für die Begattung zur Ausbildung. Die ovalen Eier sind festschalig."

Hitherto the descriptions of the fossil remains of this genus from the Coal Measures of Great Britain have been confined to examples of the spines variously considered as those of *Pleuracanthus* or *Orthacanthus* and teeth named *Diplodus*. The discovery of a number of isolated spines in the Coal Measures of the West Riding of Yorkshire,* exhibiting a very varied series of forms, has led to the conclusion that the spines named by Agassiz, as above, can only be regarded as modifications of the same genus. *Diplodus* teeth have been found associated almost indiscriminately with both forms of spine, and render the possibility of any distinction into genera still more remote. In other instances the teeth

* Quart. Journ. Geol. Soc., vol. xxxvi., p. 322, pl. XII., and woodcuts. 1880.

found associated in a single jaw are so divergent in form that specific distinction of isolated examples becomes quite problematical. The spines certainly offer more persistent and better defined characters than the teeth. A comparison of the figures of the teeth in the fine series of specimens it is now proposed to describe from the Newcastle coal field will confirm this view. Had all the teeth been obtained as individual specimens they might reasonably have served for description as different species. Notwithstanding these difficulties, the occurrence of numbers of apparently well-defined and persistent forms, sometimes found only in one locality and stratum, and in others characteristic of several localities, renders necessary their description as separate species.

In addition to the isolated specimens of spines and teeth there have been found masses of shagreen, with an occasional well-preserved archipterygial fin, or single specimens of spinous or interspinous processes, in the Coal Measures of the West Riding of Yorkshire; but the most valuable and interesting series of specimens has been discovered in the Lowmain coal seam at Newsham, in Northumberland, and is contained in the Atthey collection, recently purchased by Lady Armstrong, and placed in the museum at Newcastle-on-Tyne. From the same locality, a second collection, containing most remarkable examples, has been acquired by Mr. William Dinning, of Newcastle. Examples from both collections are described in the following pages. The fishes varied very much in size, from an example measuring nearly half a metre across the head and with a possible length of three or four metres, to a head represented by the exquisitely preserved cranium in the possession of Mr. Dinning, which has a diameter of only one-tenth of a metre. The latter specimen is the only one found on this side the Atlantic exhibiting a cranium in which the several elements are separated by sutures. The beautiful series of examples found in Bohemia and described by Dr. Fritsch; or those equally well, or perhaps better, preserved found at Commentry, in France, and described by M. Chas. Brongniart, exhibit the cranium only as a mass of cartilage without segmentation. The fossil remains described by Professor Cope as "Didymodus," obtained from the Permian beds of Texas, possessed crania which showed the component parts forming a continuum displaying distinct segments. The example in the collection of Mr. Dinning exhibits the surface configuration of the cranium with great clearness.

The upper and lower jaws are exhibited, in relative position to each other, in a very fine specimen at the museum at Newcastle. The specimen was excavated and developed by the late Mr. Atthey. On one side of the slab the two lower jaws are preserved, with large cranial plates lying near, and on the opposite side the upper jaws are exposed, with numerous teeth, as well as the reverse sides of the plates exhibited with the lower jaws. This specimen probably

indicates the largest example of the genus known; and compared with the complete examples obtained from the strata of Bohemia or Commentry, the Newsham fish must have been between three and four metres in length.

The lower jaws are 0·45 m. in length, the posterior part of the jaw is 0·11 m. in height, and diminishes to about half that amount anteriorly. As in the lower jaw exhibited in Plate LXV., its posterior portion appears to have had centres of ossification bounded by more or less angular borders (fig. 1*a*), and giving it the appearance of being composed of a series of plates. The left jaw (fig. 1*b*) is in a normal position, the right has been to some extent flattened out, which gives a more largely expanded surface than it probably possessed in a natural state. The outer borders of the two lower jaws correspond in position with those of the upper jaws exhibited on the opposite side of the slab, and the latter have impressed their form on the former, giving them the appearance of having a thicker border than they really possess, but for which they would no doubt have got credit had the specimen been less perfect. Numerous teeth are scattered between and about the jaws. The right ramus of the lower jaw is somewhat broken, as shown in the figure, but the depression of the surface (fig. 1 *a a*) may indicate the position where articulation has been. A thickening of the bone appears to show that the articulating surface was in its immediate vicinity.

To the right of the left mandible (fig. 1*b*) there are two or more large cranial plates. The one marked (fig. 1*d*) is 0·20 m. in length and 0·13 m. in breadth; it has a convex outer margin corresponding in curvature with the inner one which is concave. Both ends of the plate were probably attached to other bones; the outer convex margin is thicker and stronger than the other parts. The form of this plate is similar to the one marked (*a*) in Mr. Dinning's specimen (Pl. LXVII., fig. 2) which occupied a position on the margin of the cranium in a line with the occipital plates. Another large osseous plate (fig. 1*e*) occupies an area in advance of the one described. The mass is 0·24 in length, and may consist either of a single plate or more probably of two; it is more rectangular than the one mentioned before, and probably extended in front of it towards the anterior part of the skull.

The opposite side of the specimen is no less interesting. The palato-pterygoid constituting the upper jaws are exposed as well as the cranial plates marked *d* and *e* of the figures of the other side. The outer margin of the jaws is nearly circular (Pl. LXVI.), and from right to left the diameter is 0·43 m. A line drawn from the symphysis of the rami to the posterior extremities of the jaws is 0·44 m. in length. The outer margin of the jaws is thicker than the remaining portion, and as previously observed has impressed its form on the opposing lower jaws. The posterior extremity of the right jaw, which is perfectly exposed, is narrow, the inner margin being concave and the diameter 0·07 m. at a distance of 0·07 m. from the end. From that point it rapidly expands and joins up to the opposing

jaw with a long straight suture extending along the median line of the palate. Its broadest part is 0·14 m. The inner margin is comparatively thick, but much less so than the outer margin; the intermediate area is apparently thin, but of the same chondroid or granular structure as the other portions, the usual osseous centres being abundantly intermixed with the cartilaginous base.

The wide expansion of the palato-pterygoid bone over the palate is remarkable. The researches of Dr. Anton Fritsch have shown that the bone in the palatine region extends high up the side of the head, diminishing anteriorly and extending to the snout in a more or less attenuated form. This magnificent specimen exhibits a lateral expansion from the anterior portion of the jaws, so as to form a pair of osseous plates extending to the median line of the palate and there joining together. In the German specimens of *Pleuracanthus* (*Xenacanthus*) Dr. Kner considered that the upper jaw was divided into maxillary and premaxillary, but in this specimen there is no evidence of this unless the elements at the nasal extremity can be so construed. The Texas example, described by Professor Cope, showed the upper jaw to consist of a single bone on each side the palato-pterygoid. This view is also supported by the specimens described by Dr. Fritsch.

The large expansion of the palato-pterygoid over the palatal area of the mouth in this specimen does not extend to the anterior extremity of the jaws, but a triangular area starting at a point where the two rami are most anteriorly in juxtaposition, 0·08 m. from the nasal extremity, is occupied by a number of smaller semi-osseous pieces mixed with numerous teeth; these apparently completed the anterior portion of the wide rounded snout, and probably represent the premaxillary. There is at the anterior termination of the palato-pterygoid a thickened concave margin which has apparently served for attachment to the pieces composing the snout. The several parts, however, are not so well preserved as to enable a reproduction of the natural arrangement to be made (Pl. LXV., fig. 1 *c c*). This peculiarity is indicated in the specimen described by Dr. Jordan in the Neues Jahrbuch in 1849, and afterwards figured by Dr. R. Kner,* in which the under surfaces of the upper jaws are exhibited, separated by a distinct interval at the anterior extremity.

The teeth are numerous and vary considerably in form. The average length is 0·015 from the base to the extremity of the denticles. The form may have borne some relationship to the position the teeth occupied in the mouth, but in this specimen, as in nearly all the others, the teeth are scattered in indiscriminate confusion over the slab, and only a very rough estimate can be made as to their original position. There are a few teeth, however, which appear to be in their proper places attached to the anterior portions of the jaws. They are smaller

* Sitzungsberichte Kaiser. Akad. Wiss. Wien, vol. lv., pt. I., p. 568, pl. VI., fig. 1. 1867.

than the majority, which probably occupied a posterior position. The lateral denticles are comparatively strong, and they are considerably bent inwards; the median denticle is shorter and thicker than that of the teeth further back (Pl. LXVI., fig. 2). From an examination of the examples figured it will be observed that they offer a considerable variation in form, and taken independently would probably have been considered to represent fishes of distinct species.

The shoulder-girdle, together with bony masses of the branchial arches, are preserved on a slab obtained from the roof of the Lowmain coal seam near Newcastle, now in the collection of W. Dinning, Esq., of that city. The bones of the scapular arch to which the pectoral fins were attached (Pl. LXVII., fig. 1 *a*, *b*) occupy approximately a natural position. They are large, well-developed chondroid structures. The scapular elements enumerated by Dr. Anton Fritsch* appear in this specimen to be fused into one piece, no lines of demarcation being visible. The central portion of the specimen is occupied by portions of the branchial arches, those on the left side (c, c_1, c_2, c_3, c_4) being five in number, whilst on the right only four can be distinguished (d, d_1, d_2, d_3). A large and massive osseous element (e), partly projecting and partly under the right scapular arch, is probably the hyo-mandibular. Scattered over the slab are a number of the small stemmatoid ossicles (fig. 1*g*) previously described, which have been separated from the branchial arches. A peculiar bone of a tripartite character occupies a position behind those mentioned above. It has a length of 0·025 m. along its median axis, extending antero-posteriorly (fig. 1*f*), at a distance of about one-fourth its length from the posterior extremity; a branch extends from each side, 0·011 m. in length; 0·005 in diameter at the base of attachment, and diminishing to a point at the distal extremity. The derivation of this bone is not quite clear, but it may have been attached to the occipital region of the skull, and served as a base for the attachment of the cephalic spine.

Dr. Anton Fritsch describes the genera *Pleuracanthus* and *Xenacanthus* as being possessed of seven gill arches.† The principal evidence is afforded by a specimen of *Xenacanthus Decheni*, Goldf., from the limestone of Oelberg, near Braunau. The specimens of *Pleuracanthus* are from the gas coal of Tremosa, near Pilsen, and are more or less imperfect. Dr. Fritsch intimates that the true definition of the gill-arches is very difficult, and so far as the *Pleuracanthus* is concerned he should not hold the evidence sufficient were it not for the proof that the allied genus *Xenacanthus* could be shown to have had seven gill-arches on each side. The first arch is weak; the second to the fourth are similarly strong and longer; the fifth is shorter; the sixth still shorter; and the seventh is much thicker

* Fauna der Gaskohle, vol. iii., pt. I., p. 41, fig. 240 (woodcut).

† Fauna der Gaskohle, vol. iii., pt. I., p. 8, pl. XCIII., fig. 3; pl. XCIV., fig. 1; and p. 25, pl. XCVI., fig. 1, woodcuts 193 and 215.

and stronger, with a rough surface for the attachment of gill-rakers. M. Brongniart * states that one of the specimens he described exhibited four grooves on the surface, which probably represented the branchial arches. "Ce qui vient corroborer cette opinion, c'est qu'il existe à leur base de petites rayons, visible sur tous les examplaires et qui assurément ne sont autre chose que la charpente des branchies." In the example now described the evidence appears to be with the French specimens, a matter of some importance in relation to the classification of the genus.

A remarkable specimen in the collection of W. Dinning, Esq., of Newcastle, also from the Lowmain coal seam, is represented on Plate LXVII., fig. 2. It exhibits the bones comprising the upper surface of the cranium. The specimen has been slightly crushed, and some of the lateral bones are displaced, as shown in the figure. This specimen, along with others in his collection, has been most carefully extricated from the matrix, and is a model of what may be done by skilful and painstaking application. The bones of the median part of the skull are undisturbed, whilst those occupying positions on each side have been subject to lateral pressure and to some extent overlap each other. The bones, if they may be so termed, or plates, are all of nearly uniform thickness, 0·003 m., and where one has been forced over another, the plates are bent, and have received the impress of the one above or below respectively, which appears to indicate very clearly, that whilst the plates were sufficiently osseous to maintain their outward shape, they were so plastic that their surface conformed readily to that of a contiguous substance.

The central portion of the cranium is formed by a pair of subtriangular plates joined by a straight median suture; they are broad posteriorly, the anterior margins being equal to half the breadth of the posterior ones; these probably represent the parieto-frontal bones (*a*). Behind these the occipital (*b*) occupies a median position. At the junction of the frontals with the occipital there is a small foramen; and behind, the under surface is strengthened by a large ridge, more or less circular, which probably afforded an attachment for the cephalic spine (Pl. LXVII., fig. 3). On each side the occipital, and attached to it and to the posterior margins of the frontals, are a pair of plates (*c*) almost equal in size to the occipitals; and beyond these again, completing the posterior portion of the cranium, are a pair of large plates exceeding in size either of the intermediate ones. The plate to the right of the specimen is in its natural position; the one on the opposite side is squeezed forward and covers some of the smaller bones forming the left portion of the cranium and also a part of the left frontal (fig. 2 *d*). On each side the frontals, and parallel with their margins, are two smaller plates (*e*,*f*); outside the anterior ones the orbits probably existed, but in this specimen

* Études sur le terrain houiller de Commentry, vol. ii., pt. 3, p. 9. 1888.

the lateral plates are squeezed towards the middle, so that the orbits are more a matter of inference than certainty. Outside these again, and forming the lateral margin of the cranium on each side, are two plates (*g* and *h*) represented approximately in their natural position in figure 2 *a*, and in figure 2 by the same letters. Both the plates have been displaced, the anterior portion of each being pressed under the preceding one. The form of each, however, is clearly seen on the under surface of the specimen. Anterior to the frontals, and occupying a median position, is a small hexagonal plate (*x*). To it are attached, besides the frontals, the inner lateral plates (*f*), and in front, extending towards the snout, a pair of large semi-rhomboidal plates (*i*, *i*). The posterior margins of these are joined to the anterior margins of both the inner and outer lateral plates.

The cranium thus constituted is circular in front, expanding backwards and forming a wide extension in the occipital region. The width across the latter is about 0·10 m., and the distance from the anterior extremity of the snout to the outer margin of the occipital plate is 0·07 m.

The arrangement of the teeth is exhibited very clearly in a specimen in the collection of Mr. George Wild, from the Thin Bed Coal at Burnley in Lancashire (Pl. LXVIII., fig. 4). The teeth are comparatively small, their total length being 0·007 m., of which the basal part occupies 0·002 m., and the two principal cusps 0·005 m. The cusps are long, slender, divergent; between the two, the median cusp ascends; it is fully half the length of the principal ones, very graceful and slender. Posteriorly at the base of the two principal cones there is a large and prominent circular bulb; the base of the tooth is antero-posteriorly broader than it is between the two sides. More than fifty teeth are preserved in this slab, and appear to be derived from both the upper and lower jaws. Two or three rows are preserved in sequence. In one row there are six teeth, and in another there are five (fig. 4). These are probably from the lower jaw. The opposing teeth have the cusps pointing in the opposite direction and towards those of the upturned ones of the lower jaw; they are not in rows, but more or less disturbed; they are smaller than the others, and the median cusp is longer in proportion to the lateral ones, otherwise the teeth possess similar characters. They are of the form described by Mr. A. Smith Woodward as *Diplodus tenuis*, and as this is now shown to be associated with *Pleuracanthus* (*Diplodus*) *gibbosus*, the Burnley specimens must also be included. Though in this specimen there is not any appreciable variation in form, this may be due to the small portion of the whole mouth which is preserved.

The specimen (Pl. LXIX.) is from the Atthey collection, presented to the Newcastle Museum by Lady Armstrong, and exhibits the right ramus of the lower jaws (*a*) with a portion of the left ramus connected to it at the symphysial extremity (*b*). The length of the jaws is 0·36 m. The greatest

depth is near the posterior extremity where the jaw is 0·08 m., thence it becomes less towards the symphysis, near which the jaw has a depth of 0·03 m. Posteriorly the extremity consists of a concave articulatory surface (*a′*) by which it was attached to the palato-pterygoid. The substance of the jaw is crushed, and appears to indicate that it was not sufficiently strong to resist the pressure of the superincumbent matter. At the same time the fractured surfaces show that it was by no means elastic. The anterior extremity was probably of a firmer or more osseous consistence than the bulk of the jaw behind; but from the symphysis backwards the lower part of the jaw had a similar texture, as indicated by the compact structure of the fractured surfaces. The dentary surface was also of a firmly osseous substance, but the part of the mandible between the two has the appearance of having had a thin osseous covering, protecting an internal mass of more or less cartilaginous matter. The surface of the bone is rugose, and where fractures have exhibited the internal structure its chondroid character is clearly seen, the osseous centres presenting very much the appearance of a piece of oolitic limestone, except that the colour is black. The dentary surface is hidden by a large number of teeth; the latter have been displaced and are heaped together in a confused mass (*c*, *c*). The left mandible is in a great part hidden by the teeth, the anterior portion (*b*) is exposed compressed behind the right one. The lower jaws appear to have extended beyond the upper one, but probably not to the extent indicated by the anterior extremity of the upper jaw (*d*).

The teeth present considerable variety of forms; they are, however, so indiscriminately mixed that it is only possible to roughly estimate the position they occupied in the jaws, and the difference in form due to their location. Besides the typical examples hitherto regarded as *Diplodus gibbosus*, Ag., others with more slenderly elongated cusps have been recognized by Mr. A. Smith Woodward as identical with the teeth he has described as *Diplodus tenuis*.* Another form presents very much the appearance of *Pleuracanthus* (*Triodus*) *sessilis* described by Dr. Jordan; † and the typical forms selected by Dr. Anton Fritsch ‡ as representing the three genera, *Orthacanthus*, *Pleuracanthus*, and *Xenacanthus*, may all be found in the teeth from the jaws of this specimen (Pl. LXVI.).

On the lower part of the slab are two series of bones which are displaced, and probably represent the branchial arches. They each consist of four or five osseous elements connected together and having a semicircular arrangement. The bones are similar in character to those of the jaws, consisting of closely impacted

* Catalogue of the Fossil Fishes in the British Museum, pt. I., p. 11, pl. VI., figs. 2–4.

† Neues Jahrb., p. 843. 1849.

‡ Fauna der Gaskohle und der Kalksteine der Permformation Böhmens, vol. ii., pt. IV., p. 99, woodcuts, figs. 173 A, 174 C, and 175 B. 1889.

osseous centres in a cartilaginous framework. They are larger at the proximal end of the series and diminish in diameter towards the opposite one (*cf.* I., II., III., IV.). They may be compared with the specimens figured by Dr. Fritsch of the branchial arches of *Orthacanthus Kounoviensis*, Fr., a large species comparable with this one, in which the branchial arches are composed of a series of four or five separate semi-osseous parts.*

Separated from, but near the branchial arches, are a number of small denticulated ossicles, which were probably attached to the gill-arches. They consist of a series of small, sharp denticles, attached to a broad base. The arrangement of the denticles varies in nearly every example. Those represented on Pl. LXX., figs. 2, 3, are from the slab now described; others have been found in the Coal Measures of Staffordshire, Lancashire, and Yorkshire.

The example represented by fig. 4 was found associated with the remains of *Pleuracanthus*, near Wigan; it has seven irregularly disposed denticles attached to a more or less triangular base. The denticles are elongated, smooth, and pointed. Mr. G. Wild has examples which he has collected from the Middle Coal Measures of Lancashire, one of which, with 16 or 17 prongs, is represented by fig. 5.

Mr. John Ward has found a considerable number of similar objects in the Ragmine Ironstone Shale, at Fenton in Staffordshire, associated with teeth and other remains of *Pleuracanthus* (figs. 6–10). They exhibit a great variety in the form and arrangement of the denticles, but notwithstanding the difference in the number of the denticles and the varied manner in which they are attached to the base, there is a general similarity of construction which appears to indicate uniformity of purpose.

Similar objects were found in the fish-bed of the Upper Burlington Limestone of the Lower Carboniferous Rocks of America. Messrs. St. John and Worthen,† who described the remains, considered them of so anomalous and withal variable character as seemingly to indicate representatives of several distinct though closely-allied generic groups. Subsequently they were regarded as the teeth of a single genus, which was named *Stemmatodus*, and the so-considered teeth were divided into several species. They were supposed to have occupied the tongue or back part of the mouth of fish similar to *Dipterus* or *Ceratodus*. Mr. A. Smith Woodward‡ regards the specimens described by Messrs. St. John and Worthen, as well as those from Fenton in Staffordshire, as the dermal tubercles of some of the Elasmobranchs, and this opinion is accepted by Mr. John Ward.§

* *Op. cit.*, pt. IV., p. 108, pl. LXXXIV.

† Palæontology of Illinois, vol. vi., p. 328. 1875.

‡ Catalogue Foss. Fishes, vol. i., p. 248. 1889.

§ Trans. of North Staffordshire Inst. of Min. and Mech. Engineers, vol. x., p. 153, pl. II., fig. 22. 1890.

Dr. Anton Fritsch* discovered and described a number of similarly denticulated fossil remains attached to the gill-arches of Pleuracanths in the Gaskohle of Bohemia. A comparison of the figures of the specimens described by Dr. Fritsch with those now figured from the English Coal Measures will at once demonstrate the identity of their origin and purpose.

The specimen from the Lowmain coal seam at Newsham, represented on Pl. LXX., is the head of a large specimen, much crushed and displaced, but exhibiting some interesting features. The mass preserved on the slab is 0·37 m. from front to back, and 0·27 m. across the head. A large spine of *Pleuracanthus lævissimus*, Ag., extends from the centre of the slab, apparently the middle of the head; it is 0·17 m. in length, but the anterior part of the spine is absent. The base of the spine, extending to the part on which the denticles are present, is about 0·14 m. in length; and had the whole of the spine been preserved, a comparison of this with other perfectly preserved specimens, indicates a length of 0·22 m. The base of the spine has a diameter of 0·013 m., and higher, where the denticulated surface begins, the diameter is 0·01 m. The surface of the spine has the striated appearance characteristic of the species, and the denticles are similar to those already described as *P. lævissimus.* As to the manner in which the spine was attached to the cranium, this specimen does not give much information; there are a number of semi-osseous structures in immediate proximity to the base of the spine, and to these it may probably have been attached, but the method of its attachment is not shown.

Immediately below, and almost parallel with the spine, there extends the right ramus of the lower jaw, crowded with teeth; it originally extended beyond the margin of the slab, but is imperfect. The teeth are similar to those exhibited on Pl. LXIX., and are those known as *Diplodus gibbosus*, Ag. The vertical arrangement on the alveolar surface is well shown; there were four teeth, possibly more, in each row, which lie closely parallel to each other. Nineteen or twenty vertical rows of teeth may be distinguished, and the extremity of the jaw being absent the total number would be larger. Besides the teeth of this jaw, there are numerous others scattered over the slab intermingled with masses of bony structure representing the semi-osseous cranial plates. The latter are too much disturbed to allow their relative natural position to be made out.

The occurrence of the spine, *Pleuracanthus lævissimus*, Ag., and the teeth, *Diplodus gibbosus*, Ag., on this specimen is of importance, because it removes any doubt as to the identity of the series of specimens obtained from the Lowmain coal seam.

The specimen figured on Pl. LXXI. is from the collection of W. Dinning, Esq.,

* *Op. cit.*, p. 105, pl. LXXX., figs. 1–12, &c.

of Newcastle-on-Tyne. It exhibits a part of the body and the posterior portion of the head, with a number of teeth. Several detached cranial plates (*b*, *b*) and a large bone (*a*), which probably represents the lower jaw, are present. Associated with these are many spinous and interspinous bones. The latter are long, straight, and slender; of a dense bony structure, apparently similar to that of the spines. The spinous apophyses are much dilated at the proximal extremity, which was attached to the sheath of the notochord (*c*, *c*). The teeth are those of the so named *Diplodus gibbosus*, medium size; the lateral prongs are slender and attenuated, and the median denticle is also comparatively long.

The long interspinous rays are frequently met with in the coal fields where remains of *Pleuracanthus* occur. On Pl. LXXI. two interspinous rays are figured, natural size; one measuring 0·12 m. and the other 0·125 m. Along with these were found examples of the surapophyses, three of which are represented on the same Plate (fig. 4). They vary from 0·01 to 0·015 m. in length.

A specimen exhibiting the left pectoral fin is represented on Pl. LXV., fig. 2. The part preserved is 0·1 m. in length, and comprises a portion of the pterygium, with a mass of fin-rays attached to its outer border, and a smaller series on its inner one. The constitution of the central axis is not well preserved. The outer series of fin-rays number in this specimen twenty-two or twenty-three; the longest are 0·09 m. in length, and each is divided into about ten parts articulated together. The articulated segments are longest in the median part of the ray, shorter towards the axis, and pointed at the distal extremity; they have an average diameter of 0·002 m. The rays are semi-osseous, and have the usual granular appearance. The fin-rays springing from the inner surface are shorter and more slender; they are little more than half the diameter of those on the opposite one.

The form and constitution of this fin differ considerably from those described by M. Brongniart* and Dr. Fritsch.† There are a larger number of rays, and each is divided by a greater number of articulations. The rays attached to the segments of the pterygium, near the basal extremity, are proportionately longer than those of the French or Bohemian fishes.

The specimen figured is from the cannel coal at Tingley, in the West Riding of Yorkshire, and is in the collection of the writer.

* Études terr. houil. Commentry, p. 25, pl. IV.

† Fauna der Gaskohle Böhmens, vol. ii., pt. IV., p. 99.

Pleuracanthus lævissimus, Agassiz.

(Pl. lxxii., figs. 1–9.)

I.—Spines.

Pleuracanthus lævissimus, .	Agassiz, L., 1837, "Poiss. foss.," vol. iii., p. 66, pl. xlv., figs. 4, 5.
Pleuracanthus planus, . .	Agassiz, L., 1843, *tom. cit.*, p. 177 (name only).
Pleuracanthus lævissimus, .	Morris, J., 1854, "Cat. Brit. Foss.," p. 339.
Pleuracanthus lævissimus, .	Barkas, T. P., 1873, "Coal Meas. Palæont.," p. 17, pl. i., figs. 14–16.
Pleuracanthus lævissimus, .	Ward, J., 1875, "Proc. N. Staffs. Nat. Field Club," p. 225.
Pleuracanthus lævissimus, .	Davis, J. W., 1880, "Quart. Journ. Geol. Soc.," vol. xxxvi., p. 325 (woodcut).
Pleuracanthus pulchellus, .	Davis, J. W., 1880, *loc. cit.*, vol. xxxvi., p. 327, pl. xii., fig. 2.
Pleuracanthus planus, . .	Davis, J. W., 1880, *loc. cit.*, vol. xxxvi., p. 329.
Pleuracanthus elegans, . .	Traquair, R. H., 1881, "Geol. Mag.," ser. ii., vol. viii., p. 36.
Pleuracanthus lævissimus, .	Traquair, R. H., 1888, *loc. cit.*, ser. iii., vol. v., p. 101.
Pleuracanthus lævissimus, .	Etheridge, R., 1888, "Foss. Brit. Islands."
Pleuracanthus lævissimus, .	Woodward, A. S., 1889, "Cat. Foss. Fishes Brit. Mus.," pt. i., p. 5.
Pleuracanthus elegans, . .	Woodward, A. S., 1889, *loc. cit.*, pt. i., p. 9.
Pleuracanthus lævissimus, .	Ward, J., 1890, "Trans. N. Staffs. Inst. Mining and Mech. Engin.," vol. x., p. 134, pl. iii., fig. 8.
Pleuracanthus lævissimus, .	Woodward & Sherborn, 1890, "Cat. Brit. Foss. Verteb.," p. 154.
Pleuracanthus elegans, . .	Woodward & Sherborn, 1890, *loc. cit.*, p. 154.

II.—Teeth.

Diplodus gibbosus, Agassiz.

Diplodus gibbosus, . .	Binney, E. W., 1841, "Trans. Manchester Geol. Soc.," vol. i., p. 169, pl. v., figs. 17, 18 (name and figure only).
Diplodus gibbosus, . .	Agassiz, L., 1843, "Poiss. foss.," vol. iii., p. 204, pl. xxii. *b*, fig. 1 (*non* figs. 2–5).
Diplodus gibbus, . . .	Garner, R. 1844, "Nat. Hist. Staffs.," pl. e., fig. 11.
Diplodus gibbosus, . .	Williamson, W. C., 1851, "Phil. Trans.," p. 680.
Diplodus gibbosus, . .	Morris, J., 1854, "Cat. Brit. Foss.," p. 325.
Dittodus parallelus, . .	Owen, R., 1867, "Trans. Odontol. Soc.," vol. v., p. 325, pl. i.
Dittodus divergens, . .	Owen, R., 1867, *tom. cit.*, p. 334, pl. ii.
Ochlodus crassus, . .	Owen, R., 1867, *tom. cit.*, p. 346, pl. v.
Aganodus apicalis, . .	Owen, R., 1867, *tom. cit.*, p. 359, pl. ix.
Aganodus undatus, . .	Owen, R., 1867, *tom. cit.*, p. 362, pl. x.
Pternodus productus, . .	Owen, R., 1867, *tom. cit.*, p. 363, pl. xi.
Diplodus gibbosus, . .	Hancock, A., & T. Atthey, 1870, "Nat. Hist. Trans. Northumb. and Durham," vol. iii., p. 111.
Pleuracanthus (Diplodus) gibbosus,	Ward, J., 1875, "Proc. N. Staffs. Nat. Field Club," p. 244.
Diplodus gibbosus, . .	Ward, J., 1889, "Trans. N. Staffs. Inst. Mining and Mech. Engineers," vol. x., p. 138, pl. ii., fig. 3.
Diplodus gibbosus, . .	Woodward, A. S., 1889, "Cat. Foss. Fishes Brit. Mus.," pt. i., p. 10.
Diplodus gibbosus, . .	Woodward & Sherborn, 1890, "Cat. Brit. Foss. Verteb.," p. 66.

Diplodus tenuis, A. S. Woodward.

Diplodus gibbosus, . .	Agassiz, L., 1843, "Poiss. foss.," vol. iii., p. 204, pl. xxii. *b*, figs. 2–5.
Pleuracanthus (Xenacanthus) gibbosus,	Salter, J. W., 1861, "Foss. S. Welsh Coalfields" (Mem. Geol. Survey, Iron Ores Gt. Britain, pt. iii.), p. 224, pl. i., fig. 10.

Diplodus gibbosus, . . . Barkas, T. P., 1873, "Coal Meas. Palæont.," p. 16, pl. i., figs. 6, 7, 9–13.

Diplodus gibbosus, . . . Barkas, W. J., 1874, "Monthly Rev. Dental Surgery," vol. ii., p. 346, figs. 1–4.

Diplodus tenuis, . . . Woodward, A. S., 1889, "Cat. Foss. Fishes Brit. Mus.," pt. i., p. 11, pl. vi., figs. 2–4.

Diplodus tenuis, . . . Ward, J., 1889, "Trans. N. Staffs. Inst. Mining and Mech. Engin.," vol. x., p. 140, pl. ii., fig. 1.

Diplodus tenuis, . . . Woodward & Sherborn, 1890, "Cat. Brit. Foss. Verteb.," p. 67.

III.—Gillrakers.

Stemmatodus, St. John & Worthen.

Stemmatodus, . . . St. John & Worthen, 1875, "Palæont. Illinois.," vol. vi., p. 328.

Stemmatodus, . . . Woodward, A. S., 1889, "Cat. Foss. Fishes," vol. i., p. 245.

Stemmatodus, . . . Ward, John, 1890, "Trans. N. Staff. Inst. Mining and Mech. Engineers," vol. x., p. 153, pl. ii., fig. 22.

Stemmatodus, . . . Woodward & Sherborn, 1890, "Brit. Foss. Verteb.," p. 188.

The teeth of *Pleuracanthus lævissimus*, Ag., vary greatly in form; there are two principal cones, circular, or more or less compressed, with or without lateral cutting edges, sometimes striated. The cones are divergent, and frequently exhibit a slightly sygmoidal curvature. Between the two outer denticles is a smaller intermediate one, which may be short and compressed or comparatively long and slender. On the posterior surface behind the smaller intermediate denticles is a "button," which forms the seat on which the anterior part of the base of the succeeding tooth rested. The "button" is of irregular size, sometimes prominent, at others scarcely discernible, which is probably due to the different relative positions occupied by the teeth. Base broad, extending backwards, inferior surface more or less flattened.

The spines of *Pleuracanthus lævissimus* are straight, broad at the base, and tapering upwards to a more or less pointed apex; compressed antero-posteriorly,

but towards the distal extremity circular in section; surface smooth. Double row of reflexed, acuminate denticles, one on each lateral margin and extending along two-thirds the length of the spine. An internal cavity extends from the base upwards. Towards the distal end the internal cavity is small, lower it is large, and the walls of the spine are thin; they are frequently crushed. The base of the spine, when preserved, is contracted at the extremity, and the portion embedded in the integuments was not proportionately large. The large groove stated by M. Agassiz* to extend along the inferior surface of the spine does not always exist in the specimens examined; the appearance may have been due to crushing. The only other record of a similar groove is in the spines of *Pleuracanthus parallelus*, Fr.,† from the gas-coal of Nyran, in Bohemia.

The base of the spine represented on Pl. LXXII., fig. 1, is worthy of note. It is widely and rapidly expanded, which is probably, in part at any rate, due to crushing; but this will not account for the whole of the expansion.

The spines of this species vary considerably in size; the largest are about 0·3 m. in length; one specimen from Dalkeith, in the British Museum, has a length of 0·35 m. (Pl. LXXII., fig. 2). The specimen from Dudley, figured by Agassiz, is 0·22 m.; ‡ others from the Lower and Middle Coal Measures of the West Riding of Yorkshire attain the same length, whilst the graceful and well-preserved examples from the Staffordshire coal field are mostly about 0·15 m. in length.

Associated with the larger spines of the cannel coal, in the Middle Coal Measures of the West Riding at Tingley, there are a number of small spines, which have been previously described as *Pleuracanthus pulchellus* §; they are generally the same length, about, 0·04 or 0·05 m. Since describing these exquisitely beautiful little spines, when it was suspected that they might be the spines of immature fishes of *P. lævissimus*, the discovery of other examples has led to the conviction that such is their proper location, and that the difference in the number of lateral denticles, there being twenty on each side of the small examples against fifty in the large ones, may be due to the respective ages of the two, and increased growth of denticles as the spine has matured. The small imperfect spine named, but not described, by Agassiz,‖ *Pleuracanthus planus*, originally in the collection of Sir Philip Egerton, and now in the British Museum, is about half-an-inch in length, the basal end absent; the exposed surface is smooth and flat, and six or seven strong denticles extend along each lateral margin. It is recorded as coming from

* Poiss. foss., vol. iii., p. 66, pl. XLV., fig. 5.

† Fauna der Gaskohle und der Kalksteine der Permformation Böhmens, Band III., Heft. 1, pls. XCI. and XCIV.

‡ Poiss. foss., vol. iii., pl. XLV., fig. 6.

§ Quart. Journ. Geol. Soc., vol. xxxvi., p. 327, pl. XII., fig. 2.

‖ *Op. cit.*, p. 177.

Leeds, and was doubtless from the same locality as those mentioned above, and with them, may be included in this species.

The specimens described by Dr. R. H. Traquair* as *Pleuracanthus elegans* bear a close resemblance to the small spines from Tingley, originally described as a separate species but now included in *Pleuracanthus lævissimus.* The form, size, and number of lateral denticles is almost identical with the Tingley specimens, and if the latter are the young examples of this species, there can be little difficulty in assigning the small spine described by Dr. Traquair to this species also. The type is described as two and a-half inches in length, from the Blackband Ironstone of Borough Lee, near Edinburgh, and in the collection of R. Kidston, Esq., of Stirling.

The spines of *Pleuracanthus lævissimus*, Ag., from the cannel coal at Tingley are almost cylindrical in section as compared with those from the Fenton and Longton localities in Staffordshire. The latter are compressed antero-posteriorly, and oval in section; the spines from the Lowmain Seam near Newcastle are similar to those from Staffordshire. The lateral denticles on the Yorkshire specimens are larger and more widely separated than those of the other localities named (see Pl. LXXII., fig. 3). The number of denticles on the spines from the several localities offers considerable variety. The specimens found at Tingley, at Fenton, and the one from Newsham, represented by fig. 6 have between fifty-five and sixty denticles on each side, whilst the specimen, fig. 7, from the same locality, has only thirty-two, and the one from Shattleston, fig. 8, near Glasgow, has forty on each margin. The smallest examples, about two inches in length, average about eighteen or twenty on each side. Presuming that all these specimens are of one species, it would appear that the number of denticles increases with the age and size of the spine.

The occurrence of a large number of species represented by an abundance of specimens of each in the cannel coal of the West Riding of Yorkshire† appears to indicate that *Pleuracanthus* flourished and attained its greatest numerical development in fresh water. The cannel coal extends over a considerable area, in patches two or three miles in diameter, thickest in the centre and thinning off towards the edges, proving that it was accumulated in a series of lakes or lagoon-like depressions. The coal is a very pure carbonaceous substance with only 2 or 3 per cent. of earthy matter, and attains a maximum thickness of about two feet. To accumulate this large mass from the gradual decay of the leaves and spores shed by the plants growing in or about the lagoons would take a long time, and indicates a period of great quiet. Occasionally a stream ran through the lagoons bearing fine mud, and the latter settled along with the vegetable matter, and together

* Geol. Mag., ser. II., vol. viii., p. 36.

† Quart. Journ. Geol. Soc., vol. xxvi., p. 56.

produced an impure coal, locally termed "hubb." The fish-remains are found indiscriminately in the pure cannel and the hubb, and associated with them are myriads of Unios and fresh-water shells. The latter probably served as food for the Pleuracanths, whilst the Cœlacanths, which also existed in very large numbers, were probably vegetable feeders. Large spines of *Ctenacanthus* and *Gyracanthus* are not uncommon, and there can be no doubt that these sharks existed in the same lagoons and preyed on the smaller fish: the strong, sharply-pointed barbs with their lateral recurved rows of hooklets of the Pleuracanths would serve as an admirable defence against their more powerful adversaries.

A peculiar and abnormal specimen of *P. lævissimus* was found by Mr. George Wild, of Bardsley, in the shale forming the roof of the coal at the Arley Mine, Burnley. The specimen is imperfect. The part preserved is 0·105 m. in length, and consists of the middle part of a spine. The base and the point are wanting; the spine is oval in section, and denticles extend along each lateral margin as in the typical examples of the species. This one differs, however, from the types in several particulars. On one side of the spine there are three rows of denticles instead of one (Pl. LXXII., fig. 4), and on the opposite side there are two rows in one part of its length, whilst on the remainder there is only a single row. The latter margin is free from denticles for a distance of 0·045 m. from the basal end; whilst the margin with three rows extends the whole length of the existing part of the spine. In the shorter row there are twenty-one denticles on the median lateral line, and from the fourth to the tenth denticle the row is double (fig. 5). The denticles are strong and broad at the base; the apex curved backwards; and a groove extends along their base parallel with the length of the spine. There are thirty-three denticles in the median row on the opposite side, flanked on the one side by thirty-two denticles, smaller but of similar form, and on the other by twenty-three denticles extending from the basal end, but disappearing towards the distal extremity. The structure of the spine has the same dense character possessed by others of this species, and in other respects it is similar. The presence of the extra rows of denticles is apparently only an abnormal aberration from the type.

M. Brongniart* states that the small spine of *Pleuracanthus pulchellus*, Davis, from the cannel coal of Tingley is very nearly related to the spine of *Pleuracanthus Gaudryi*, Brong., from the Upper Coal Measures of Commentry in France; and the spine figured and described by Dr. Fritsch † as *Pleuracanthus ovalis* does not appear to differ in any essential respects. It is similar in size to *P. elegans*, Traq., and *P. pulchellus*, Davis; it has about twenty denticles on each side, and in other respects resembles the spines of immature examples of *P. lævissimus*, Ag.

* Études sur le terrain houiller de Commentry, Fauna Ichthyologique, pt. I., p. 33. 1888.

† Fauna der Gaskohle Böhmens, vol. iii., pt. I., p. 13, pl. XCI., figs. 9, 10.

The spine of *Pleuracanthus Œlbergensis*, Fr.,* is very much like the medium-sized species of *P. lævissimus*, Ag., from the Coal Measures near Glasgow. They are the same length, and each side of the spine is armed with about forty denticles. The spine of *Xenacanthus Decheni*, Goldf.,† also resembles *P. lævissimus*, Ag., both in form and size, and the number of denticles in each is the same.

Formation and Locality.—Lowmain Coal Seam, Newsham, Northumberland; Cannel Coal, Tingley; Better-bed Coal, Yorkshire; New Ironstone (Ragmine) Fenton; Arley Mine, Burnley; Shattleston, near Glasgow.

Ex coll.—Museum of Natural History, Newcastle-on-Tyne; J. W. Davis, Halifax; John Ward, Longton; James Thomson, Glasgow; W. Dinning, Newcastle-on-Tyne; George Wild, Bardsley.

Pleuracanthus robustus, Davis.

(Pl. LXXII., figs. 10–14.)

Pleuracanthus robustus, . . DAVIS, J. W., 1880, "Quart. Journ. Geol. Soc.," vol. xxxvi., p. 330, pl. XII., fig. 5.

Pleuracanthus robustus, . . ETHERIDGE, R., 1888, "Foss. Brit. Islands."

Pleuracanthus robustus, . . WOODWARD, A. S., 1889, "Cat. Foss. Fishes Brit. Mus.," pt. I., p. 7.

Pleuracanthus robustus, . . WARD, J., 1890, "Trans. N. Staffs. Mining and Mech. Engin.," vol. x., p. 136.

Pleuracanthus robustus, . . WOODWARD & SHERBORN, 1890, "Cat. Brit. Foss. Verteb.," p. 155.

Spines: the largest examples occur at Tingley; they are imperfect, the base being absent. The part preserved is 0·09 m. in length; if perfect it would probably have measured 0·11 m. The surface is covered with fine longitudinal striations. The diameter in the median part is 0·008 m., whence it tapers to a point at the distal extremity. The basal extremity is also considerably less in diameter than the median part. An internal cavity occupies rather more than one-third the diameter at a distance of 0·09 m. from the point. The spine is very slightly curved. In section the superior surface is rounded in the upper half, and more or less triangular nearer the base; the inferior surface is slightly curved, and forms a longitudinal median ridge. The angles formed by the outer edges of this

* *Op. cit.*, p. 15, pl. XCVI., fig. 3.

† Beit. Vorwelt Fauna, p. 23, pl. V., fig. 9, 1847; and Fritsch, *op. cit.*, pl. XCVIII., fig. 2.

surface with the sides of the spine are armed with a series of denticles. The denticles extend from the apex a distance of 0·04 m. They are large, strongly implanted, closely-set, recurved, and sharply pointed; about twenty on each side. The upper surface of the denticles, *i. e.* the one having the greatest curvature, is produced so as to form a miniature carina or keel, smooth and sharp (Pl. LXXII., figs. 10, 11).

Since this species was described in 1880, specimens have been found in other localities. One of these, discovered by Mr. John Ward, in the Knowles Ironstone Shale, at Fenton, is of peculiar interest (fig. 12). The dorsal or inferior surface is exposed; the spine is complete, though somewhat fractured in the median part. It is smaller than the Tingley specimens, being 0·086 m. in length. The attenuation of the basal part of the spine, which was implanted in the integument of the fish, is well shown. The walls are comparatively thin and hollow; they extend to the basal extremity only on the anterior surface; the internal cavity instead of being terminal is open a distance of 0·012 m. along the inferior surface, the walls gradually enfolding it, as shown in the figure. The number of denticles is the same as in the Tingley specimen.

This species has also been found in the Lowmain coal seam at Newsham, and a specimen is figured from Mr. Atthey's collection at the Museum at Newcastle. It is complete; 0·087 m. in length. The lateral surface is exposed, with one row of denticles, extending a distance of 0·03 m. from the point; they are fourteen or fifteen in number, and of a similar character to those already described (Pl. LXXII., fig. 13).

Spines in all respects similar to the latter are found in the cannel coal at Tingley, but of much smaller size. They appear to have belonged to fishes which were not mature (fig. 14).

Spines belonging to the fossil fish named by Dr. Fritsch *Orthacanthus pinguis*, Fr.,* bear a close relationship to this species; they are larger in size, but the robust form and the arrangement, position, and number of the denticles resemble the spines of *P. robustus*, Davis.

Formation and Locality.—Middle Coal Measures, Cannel Coal, Tingley, Yorkshire; Deepmine and Knowles Ironstone Shale, Fenton and Longton, Staffordshire; Lowmain Coal, Newsham, Northumberland; Carluke.

Ex coll.—James W. Davis, Halifax; J. Ward, Longton; Museum of Natural History Society of Northumberland and Durham, Newcastle-on-Tyne; British Museum (Nat. Hist.).

* Fauna der Gaskohle, vol. ii., pt. IV., p. 109, pl. LXXXVII., figs. 3, 4, 6.

Pleuracanthus Wardi, Davis.

(Pl. LXXII., fig. 15.)

Pleuracanthus Wardi, . . DAVIS, J. W., 1880, "Quart. Journ. Geol. Soc.," vol. xxxvi., p. 334, pl. XII., fig. 6.
Pleuracanthus Wardi, . . ETHERIDGE, R., 1888, "Foss. Brit. Islands."
Pleuracanthus Wardi, . . WOODWARD, A. S., 1889, "Cat. Foss. Fishes Brit. Mus.," pt. I., p. 10.
Pleuracanthus Wardi, . . WARD, J., 1890, "Trans. N. Staffs. Inst. Mining and Mech. Engin.," vol. x., p. 136.
Pleuracanthus Wardi, . . WOODWARD & SHERBORN, 1890, "Cat. Brit. Foss. Verteb.," p. 155.

Spine: imperfect; the part preserved consists of the median part, 0·15 m. in length. The base and upper portion are absent. It is 0·012 m. diameter nearest the base, and diminishes gradually to 0·007 m. at the part preserved nearest to the point. The front of the spine is rounded and striated longitudinally; the posterior surface is armed with a double row of denticles, forming continuous ridges, and separated only by a narrow groove. The denticulated surface extends a distance of 0·09 m.; the denticles are short and obtuse, probably due to abrasion. The spine in transverse section is depressed on each side of the lines of denticles towards the median lateral line, which is somewhat angular. The spine is arched towards the posterior surface, and the internal cavity is large in proportion to the size of the spine.

This spine more nearly approaches the characters of *Pleuracanthus cylindricus*, Ag., than any other, and it has been suggested by Mr. Ward and others that its separation from that species may be conjectural. After a careful reconsideration of the specimens, however, I am still of opinion that its long slender form and decided curvature, together with the closely approximating lines of denticles forming continuous ridges, and the form of the spine in section, separate it with sufficient distinctness from the stronger cylindrical spine and the well-defined denticular arrangement of *P. cylindricus*.

Formation and Locality.—Ragmine Ironstone Shale, Fenton, Staffordshire.

Ex coll.—John Ward, Longton.

Pleuracanthus undulatus, sp. nov.

(Pl. LXXII., fig. 16.)

Spine: straight, 0·13 m. in length, 0·01 m. in diameter at the base, gradually diminishing to the pointed apex. Section of spine, midway and higher, circular; base somewhat crushed, but apparently oval. Upper posterior surface has two rows of denticles, which are large, broad at the base, blunt and widely separated. The denticles are placed diagonally, those of one row being slightly in advance of those of the other. At a distance of 0·03 m. from the apical extremity, the two rows are separated by a space equal to one-half the diameter of the spine, and the interval between two denticles in the same row is 0·07 m. Both the distances, between the two rows, and between the individual denticles diminish gradually towards the point.

This spine is clearly distinguished from others previously described, by the large and widely separated posterior denticulation. It was found by Mr. George Wild, of Bardsley, and presented to the Manchester Museum.

Formation and Locality.—Thin-bed Coal, Fulledge Colliery, Burnley.

Ex coll.—Mr. G. Wild: Manchester Museum, Owens College.

Pleuracanthus tenuis, Davis.

(Pl. LXXII., fig. 17.)

Pleuracanthus tenuis, . .	DAVIS, J. W., 1880, "Quart. Journ. Geol. Soc.," vol. xxxvi., p. 327, pl. XII., fig. 1.
Pleuracanthus tenuis, . .	ETHERIDGE, R., 1888, "Foss. Brit. Islands."
Pleuracanthus tenuis, . .	WOODWARD, A. S., 1889, "Cat. Foss. Fishes Brit. Mus.," pt. I., p. 10.
Pleuracanthus tenuis, . .	WOODWARD & SHERBORN, 1890, "Cat. Brit. Foss. Verteb.," p. 155.

Spine: long and slender, imperfect; length preserved is 0·12 m.; diameter 0·005 m.; basal part circular in section; upper part more or less angular. Along each lateral margin for a distance of 0·07 m. there is a row of denticles, about eighteen or twenty in number, with bluntly-rounded points tipped with enamel. The spine is slightly curved. There is an internal canal, wide near the base, but converging higher up, and extending through the whole of the length.

This species is peculiar from its great length in proportion to the diameter. Its curved form distinguishes it from all other species, which have the denticles arranged on the directly opposing lateral surfaces of the spine.

Formation and Locality.—Bone-bed, Better-bed Coal, Clifton, near Halifax (Lower Coal Measures).

Ex coll.—James W. Davis.

Pleuracanthus denticulatus, Davis.

(Pl. lxxii., figs. 18–20.)

Pleuracanthus denticulatus, .	Davis, J. W., 1880, "Quart. Journ. Geol. Soc.," vol. xxxvi., p. 334, pl. xii., fig. 7.
Pleuracanthus denticulatus, .	Woodward, A. S., 1889, "Cat. Foss. Fishes, Brit. Mus." pt. i., p. 9.
Pleuracanthus denticulatus, .	Woodward & Sherborn, 1890, "Cat. Brit. Foss. Verteb.," p. 154.

Spine: base wanting; length 0·055 m.; distinctly curved; lateral and anterior face smooth; circular in section; the posterior surface is flat, with two rows of denticles separated by a distance equal to one-half the diameter of the spine. The denticles are small, closely set together, broad and strongly attached at the base, contracting suddenly, and forming a carinated apex, pointing towards the base of the spine.

There are forty-five denticles on each side on the length preserved. A somewhat large central cavity extends towards the apex.

This specimen is from the Bone-bed above the Better-bed coal, and from that locality is unique; other specimens have been found in the shale above the cannel coal at Tingley, which differ little from the type; they have similar closely set strong denticles. The sides are somewhat compressed, and towards the base have slight striæ. It is possible that if the base of the Bone-bed specimens were preserved, its surface might be ornamented in the same way. The lower part of the spine is thin, and the internal cavity large; the walls expanding towards the base. A perfect example would probably be 0·09 m. in length. They are composed of a dense bony substance (fig. 18).

This species differs from all the others obtained from the West Riding coal field in its arched form, and close, peculiar denticulation. *Pleuracanthus arcuatus*, Newberry,* afterwards described and figured by the same author as *Orthacanthus*

* Proc. Acad. Nat. Sci., Philadelphia. 1856.

arcuatus, Newb.,† is a spine closely allied to the one now described. It was found associated with, and buried in, an "ill-defined mass of granular material, which represents in the cannel coal the partly-ossified cartilage that composed the hard parts of the head of *Diplodus*. With them are also groups of *Diplodus* teeth still attached to the jaws." The spines were arched and tapering, and striated on the surface, and the posterior face flattened, or raised into a low ridge along the median line, and on each side of it a row of closely set acuminate depressed hooks. The hooks or denticles of the Linton species are apparently longer and more numerous than those from the Better-bed coal, but they closely resemble the Tingley specimens, especially in the striation of the surface of the spine. The Linton spines are from cannel coal.

P. denticulatus has been found in the Lowmain coal seam at Newcastle. A specimen almost perfect is 0·085 m. in length: the denticulated posterior surface extends from the apex 0·04 m., and is armed with a double row of barbs, about forty in number, on each side. The basal half of the spine is uniform in diameter, except quite near the base, which is smaller. The surface is covered with minute longitudinal striæ, similar to that of the Yorkshire specimens (fig. 19).

A specimen in the collection of Mr. George Wild, from the shale above the two-feet coal at Bardsley, in Lancashire, is identical with this species. The base of the spine is not preserved, the upper portion is slightly arched backwards, and a row of denticles, about forty in number, are exposed, extending a distance of 0·05 m. from the point (fig. 20).

Formation and Locality.—Bone-bed, Better-bed Coal, Clifton and Lowmoor; and Cannel Coal, Tingley, in the West Riding of Yorkshire; Lowmain Coal, Newsham, Northumberland; Two-feet Coal, Bardsley, Lancashire.

Ex coll.—James W. Davis, Halifax; Museum of Natural History Society of Northumberland and Durham, Newcastle-on-Tyne; George Wild, Bardsley.

Pleuracanthus Howsei, sp. nov.

(Pl. LXXII., fig. 21.)

Spine: length, 0·12 m.; diameter, 0·006 m., near the base, from which the diameter gradually diminishes and terminates in a finely-pointed apex. Spine is slightly curved, more or less ovoid in section, with a double row of denticles extending along the posterior surface; from the distal extremity the denticles extend a distance of 0·05 m. The denticles are twenty-eight in each row; short,

† Palæont. Ohio, vol. i., p. 332, pl. XL., fig. 4, 1873.

blunt, about their own diameter apart. The two rows are comparatively close together. The base of the spine is preserved; it is hollow, with thin tapering walls. The cavity appears to have been terminal. The surface of the spine is finely striated.

This spine, which it is suggested should be specifically designated *Pleuracanthus Howsei*, may be distinguished from *P. denticulatus*, Davis, to which it bears a general resemblance, by the smaller number of its denticles—it having twenty-eight, whereas *P. denticulatus* has forty-five on a spine somewhat smaller than the one now described. The denticles in this species are blunt and rounded, in the other they are long, recurved and acuminate.

Formation and Locality.—Lowmain Coal Seam, Newsham, Newcastle-on-Tyne.

Ex coll.—Museum of the Natural History Society of Northumberland and Durham, Newcastle-on-Tyne.

Pleuracanthus alatus, Davis.

(Pl. lxxiii., figs. 5–13).

Pleuracanthus alatus, . .	Davis, J. W., 1880, "Quart. Journ. Geol. Soc.," vol. xxxvi., p. 329, pl. xii., fig. 4.
Pleuracanthus alternidentatus,	Davis, J. W., 1880, *loc. cit.*, p. 328, pl. xii., fig. 3.
Pleuracanthus attenuidentatus,	Etheridge, R., 1888, "Foss. Brit. Islands," pt. i., p. 337 (misprint).
Pleuracanthus altus, . .	Etheridge, R., 1888, *loc. cit.*, p. 337 (misprint).
Pleuracanthus alatus, . .	Woodward, A. S., 1889, "Cat. Foss. Fishes Brit. Mus.," pt. i., p. 9.
Pleuracanthus alternidentatus,	Woodward, A. S., 1889, *loc. cit.*, p. 9.
Pleuracanthus alatus, . .	Ward, J., 1890, "Trans. N. Staffs. Inst. Mining and Mech. Engin.," vol. x., p. 136.
Pleuracanthus alatus, . .	Woodward & Sherborn, 1890, "Cat. Brit. Foss. Verteb.," p. 153.
Pleuracanthus alternidentatus,	Woodward & Sherborn, 1890, *loc. cit.*, p. 153.

Spine: length, 0·07 m.; breadth, 0·005 m.; straight; diameter greatest in the middle and diminishing towards each extremity, the upper one ending in a point. In section the posterior face forms a depressed curve; the anterior one is semicircular; along the angles formed by the two there extends, for about one-third the length from the apex, a double row of denticles, varying in number from seven to ten on each side. The denticles are broad at the base, connected one to another

laterally, short, and terminating obtusely, with an elongated cutting edge parallel to the longitudinal axis. They diminish in size towards the point, and for about 0·004 m. the point of the spine is free. The surface of the spine is uniformly covered by minute longitudinal striæ. In most of the examples the base of the spine is crushed; its walls are thin, and the internal cavity comparatively large.

The specimen described as *Pleuracanthus alternidentatus*, Davis,* from Middleton, near Leeds, probably belongs to this species. It is slightly more robust and longer, and the spine in section is rounder; the principal difference is in the more widely separated position of the denticles and their being placed along the margins in alternate series, instead of being opposite. Since the description was written in 1881 other specimens have been found in Yorkshire and also in Staffordshire. The latter are particularly interesting because they appear to indicate a passage between the two forms; the number of denticles is smaller than those of the type specimen of *P. alatus*, but greater than those of *P. alternidentatus*, and they are placed somewhat irregularly. Taking into consideration the new evidence it appears desirable to regard the two forms as one species, and it is now suggested that *Pleuracanthus alternidentatus* be included as a synonym of *Pleuracanthus alatus*, Davis.

A small specimen from the Deepmine shale at Longton, in Staffordshire, from the collection of Mr. John Ward, is 0·017 m. in length; one half the length is armed with a double row of barbs, numbering seven or eight on each side. The characters of this example appear to indicate its relationship to *P. alatus*, and it is probably the spine of an immature fish. It is worthy of note, however, that the denticulated surface bears a much larger proportion to the whole length of the spine than in the fully grown specimens, and the distal extremity is not so pointed (Pl. LXXIII., figs. 7–9).

Examples of spines found in the Lowmain coal of Newsham occur in the Atthey collection at the Newcastle Museum. They have a length of 0·045 m. A double row of denticles extends a distance of 0·017 m., as in the type specimen, each row containing sixteen to eighteen denticles, longer, recurved, and more pointed than in the specimens from Tingley or Staffordshire. These characteristics vary considerably from the original; but the general resemblance of the form is sufficiently close to justify its inclusion. The basal extremity of the specimen figured is well exposed (Pl. LXXIII., figs. 10, 11).

Mr. James Thomson has furnished examples collected at Newarthill, Quarter Hamilton, and other localities near Glasgow, which have about ten denticles in each row, and approach very near to the type from Tingley (Pl. LXXIII., fig. 13).

Formation and Locality.—Middle Coal Measures; Cannel Coal, Tingley and Middleton, near Leeds; Knowles Ironstone Shale, Fenton; and Deepmine Ironstone,

* Quart. Journ. Geol. Soc., vol. xxxvi., p. 328, pl. XII., fig. 3.

Longton, Staffordshire; Watston; Stonehouse; Newarthill; Quarter Hamilton, Scotland; Lowmain Coal Seam, Newsham, Newcastle-on-Tyne.

Ex coll.—James W. Davis, Halifax; Museum Literary and Philosophical Society, Leeds; John Ward, Longton; James Thomson, Glasgow; Atthey Collection, Museum Natural Hist., Newcastle-on-Tyne.

Pleuracanthus erectus, Davis.

(Pl. LXXIII., fig. 14–16.)

Pleuracanthus erectus, . . DAVIS, J. W., 1880, "Quart. Journ. Geol. Soc.," vol. xxxvi., p. 326, fig. 2 (woodcut).

Spine: length, 0·09 m.; breadth at the base, 0·008 m., whence the sides converge in straight lines to an elongated and acute point; antero-posteriorly compressed; section oval, lateral margins produced, forming a series of convex, compressed projections. The projections have a broad base and are widely separated from each other. The surface of the spine is striated longitudinally.

Since the description of the original specimen from the cannel coal at Tingley, other specimens have been obtained from the same locality, which prove conclusively that the similarity to *Pleuracanthus lævissimus*, Ag., indicated in the original description,* and since emphasized by other authors,† was only a generic one. The species are quite distinct, and may be distinguished by the form and character of the denticles very readily. In this species they are broad at the base and more or less rounded, whilst in *P. lævissimus* they are long, recurved, and sharply pointed. The denticulated margin of the spine in the type specimen is 0·055 m. in length, and on this margin there are twenty-two denticles; in a specimen of *Pleuracanthus lævissimus*, Ag., from the Lowmain coal, of a similar size and with the same length of denticulated margin, there are thirty-seven denticles. This comparative paucity of denticles in *P. erectus* is characteristic of all the specimens which have come under observation. In shorter spines, which it is presumed were those of younger fishes, the disparity is still more marked, and it is equally borne out by larger ones. A very fine example (Pl. LXXIII., fig. 14), which is preserved, along with others, from the Lowmain coal seam, in the Atthey collection, may be compared with the specimen of *Pleuracanthus lævissimus*, Ag. (Pl. LXXII., fig. 1), from the same bed. In the latter there are sixty-five denticles on each margin,

* *Loc. cit.*, p. 326.

† R. H. Traquair Proc. Roy. Phys. Soc. Edinburgh, vol. ix., p. 422; A. Smith Woodward, Cat. Foss. Fishes, pt. I., p. 6

extending over 0·13 m.: on each margin of the *Pleuracanthus erectus* there are only forty-five denticles, and they occupy exactly the same area as the others.

The example last referred to has a length of 0·22 m.; at a distance of 0·07 from the basal extremity the lateral diameter of the spine is 0·012 m., and thence it gradually diminishes to an attenuated point at the distal end, and towards the base the diameter is also reduced. The spine is oval in section, compressed antero-posteriorly; its walls are comparatively thin at the basal end. The internal pulp cavity appears to have been terminal.

A spine of *P. erectus*, having a length of 0·21 m., has been found in the shale immediately above the two-feet coal at Bardsley. Other specimens, not so perfectly preserved, have been found, and associated with them examples of *P. lævissimus*, Ag. The denticulated margin of the specimen first referred to occupies 0·11 m., rather more than one-half the length of the spine; the number of denticles is thirty-one on each side. A comparison of the more or less fragmentary spines of the two species exhibits very clearly the difference in denticulation which has been observed in those from other localities.

Formation and Locality.—Cannel Coal, Middle Coal Measures, Tingley; Lowmain Coal Seam, Newsham; Two-feet Coal Seam, Bardsley.

Ex coll.—James W. Davis, Halifax; Museum of Natural History Society, Newcastle-on-Tyne; George Wild, Bardsley.

Pleuracanthus horridulus, Traquair.

(Pl. LXXII., figs. 22, 23.)

Pleuracanthus horridulus,	. TRAQUAIR, R. H., 1882, "Geol. Mag.," ser. II., vol. ix., p. 541.
Pleuracanthus horridulus,	. WOODWARD, A. S., 1889, "Cat. Foss. Fishes Brit. Mus.," pt. I., p. 9.
Pleuracanthus horridulus,	. WOODWARD & SHERBORN, 1890, "Cat. Brit. Foss. Verteb.," p. 154.

Length of spine, 1 inch; diameter at base, $\frac{1}{12}$ inch; gently arched, tapering to a point, lower part striated, upper smooth; upper third of posterior surface set with a double row of large recurved denticles, eight or nine on each side, placed alternately with each other.

The specimens referred to were described by Dr. Traquair without figures, and I have not the originals for reference; other specimens of this species from

Borough Lee have, however, been accessible, and I have before me an example from the Bone-bed above the Better-bed coal at Clifton, which corresponds exactly with the Borough Lee specimens. The spine is imperfect, the distal portion only being preserved; it is 0·015 in length, and there are eight or nine large recurved, sharply-pointed denticles; the surface of the spine is smooth. Except that the denticles are larger, the spine agrees with the smaller examples of *Pleuracanthus alatus*, Davis, and it is quite probable that additional specimens may show a gradation of the one into the other; for the present it is suggested that the specimens should be considered as a separate species.

Formation and Locality.—Bone-bed, Better-bed Coal, Clifton, Yorkshire.

Ex coll.—James W. Davis.

Pleuracanthus cylindricus (Agassiz), Davis.

(Pl. LXXIII., figs. 1–4.)

Orthacanthus cylindricus, .	AGASSIZ, L., 1843, "Poiss. Foss.," vol. iii., p. 177, pl. XLV., figs. 7–9.
Orthacanthus cylindricus, .	MORRIS, J., 1854, "Cat. Brit. Foss.," p. 335.
Orthacanthus cylindricus, .	BARKAS, T. P., 1873, "Coal Meas. Palæont.," p. 20, figs. 39–42.
Orthacanthus cylindricus, .	WARD, J., 1875, "Proc. N. Staffs. Nat. Field Club," p. 217.
Pleuracanthus cylindricus, .	DAVIS, J. W., 1880, "Quart. Journ. Geol. Soc.," vol. xxxvi., p. 331 (woodcut).
Pleuracanthus (Orthacanthus) cylindricus,	TRAQUAIR, R. H., 1888, "Geol. Mag.," ser. III., vol. v., p. 101.
Pleuracanthus cylindricus, .	WOODWARD, A. S., 1889, "Cat. Foss. Fishes Brit. Mus.," pt. I., p. 8.
Orthacanthus cylindricus, .	WARD, J., 1890, "Trans. N. Staffs. Inst. Mining and Mech. Engin.," vol. x., p. 137.
Pleuracanthus cylindricus, .	WOODWARD & SHERBORN, 1890, "Cat. Brit. Foss. Verteb.," p. 153.

Spine: erect and straight, or with a very slight curvature; attains a large size. A specimen in the collection of Mr. Ward, from the Fenton Ironstone shales, was probably not less than 0·55 m.; the base is imperfect, but the part preserved, probably the thickest, has a diameter of 0·025 m. A more perfect specimen has a length of 0·31 m., and a diameter of 0·018 m., at a distance of 0·2 m. from the apex; from this part the diameter of the spine gradually decreases upwards and ends in

an acuminate apex. In section the spine is more or less round, except at the base, which is compressed antero-posteriorly; the extremity is slightly tapering and rounded. The internal cavity is not terminal, but is open along the posterior surface for a distance of about 0·04 m. The orifice is large and the walls thin at the base; higher, the cavity is reduced to one-third the diameter of the spine, and gradually diminishes towards the apex. The surface of the spine is covered with longitudinal striations which sometimes disappear towards the apex. On the posterior surface is a double row of closely approximating denticles; they extend over one-half the length of the spine, and number seventy or eighty denticles on each side; they increase in size with the diameter of the spine or towards the base. The denticles are round near their base, contracting to an obtuse point, directed diagonally towards the base, and at the same time away from the centre, of the spine (fig. 1).

A magnificent specimen of the spine of this species is preserved in the British Museum (Nat. Hist.). It forms a part of the Egerton collection, but unfortunately there is no record of the locality from which it has been obtained. The matrix is a hard ironstone shale, and there are a number of molluscan remains on the slab, *Goniatites*, *Pecten*, and other marine forms, together with the remains of a plant, apparently *Lepidostrobus*. The spine is 0·39 m. in length, and the base is imperfect. Its greatest diameter is 0·018 m. The spine has a slight, graceful curvature, with smooth surface somewhat deeply striated longitudinally. The denticulated surface extends 0·18 m. along the posterior surface, and on each row there are fifty denticles. Those situated on the upper part are long recurved hooks, each separated from the next by a distance equal to the diameter of its own base. Midway along the denticulated surface the denticles are larger, thicker, and stronger; at the lower part they diminish again in size and are shorter and more stumpy, where not broken off in the opposing matrix of the opposite slab. (Pl. LXXIII., fig. 2).

The largest examples of this species are from the Fenton and Knowles Ironstone shales of North Staffordshire. The specimens from the Scotch Measures are smaller, and some of them, as, for example, one from Quarter Hamilton (fig. 4), in the collection of Mr. James Thomson, of Glasgow, has the rows of posterior denticles situated wider apart than those described, the intervening area being quite convex, whilst in those from Staffordshire it is flat or slightly concave (fig. 3).

The spine of *Orthacanthus bohemicus*, Fr., from the gas-coal of Nyran, in Bohemia, probably occupies a position closely allied to this species.

Formation and Locality.—Shale above the Ragmine Ironstone, Fenton; Knowles and Chalky-mine Ironstones, Longton; and Brown-mine Ironstone, Silverdale, in Staffordshire; Quarter Hamilton, Scotland.

Ex coll.—John Ward, Longton; James Thomson, Glasgow; Egerton Collection, Natural History Department, British Museum.

Pleuracanthus Thomsoni, sp. nov.

(Pl. LXXIII., fig. 17.)

Spine: distal extremity absent; length preserved 0·8 m; greatest diameter 0·06 m.; section circular, with round internal cavity. If perfect the spine would probably be 0·9 m. in length. The denticulated surface which is preserved occupies 0·18 m., and consists of a double row of eleven denticles separated by a distance of rather more than 0·02 m.; the intervening space is occupied by a ridge. The denticles are broad and obtuse, with a broad lateral depression between each. The spine is slightly curved.

This species approaches most nearly to *P. robustus*, Davis, in general appearance. It differs in being thinner in proportion to its length. The denticulated surface is shorter, and the two rows are closer together. In *P. robustus*, the denticles extend over half the length of the spine; in this one they cover little more than one-fourth. The denticles themselves are short and rounded, whilst in the former they are closely implanted, recurved, pointed, and extend from the surface a distance equal to one-half the diameter of the spine.

Formation and Locality.—Above the soft coal in the Red Sandstones at Quarter Hamilton, Kilmarnock.

Ex coll.—James Thomson, Glasgow.

Pleuracanthus obtusus, nom. nov.

(Pl. LXXIII., fig. 18.)

Phricacanthus biserialis, . . DAVIS, J. W., 1879, "Quart. Journ. Geol. Soc.," vol. xxxv., p. 186, pl. x., figs. 16, 17.

Spine: length 0·105 m.; greatest diameter 0.007 m. The spine is gently arched backwards, the exposed part covered with minute longitudinal striations. In section the spine is circular: from the apex extending 0·05 m. along the posterior surface, there is a right and left row of seven widely separated protuberances or denticles. In the lower part there is a distance of 0·007 m. between the apex of two consecutive denticles; they are broad longitudinally, laterally compressed, and rapidly converge to a rounded obtuse apex. The denticles are alternate, the projection on one side being opposite to the depression on the other; an internal

cavity, circular in form, extends upwards from the base. The walls of the cavity forming the base of the spine are thin, and in the specimen now described, they are crushed.

Mr. A. Smith Woodward* doubtfully places *Pleuracanthus biserialis* as a synonym of *Pleuracanthus cylindricus*, Ag. There is, however, a great difference between the two spines. The greatest discrepancy is in the form of the denticles ranged on either side of the dorsal aspect of the spine. In *Pleuracanthus* (*Orthacanthus*) *cylindricus*, Ag.; the teeth are more or less hooked, pointed, and close together; but, in this instance, the denticles are widely separated, rounded, and blunt; to such an extent is this the case that the term is scarcely applicable; they have more of the character of wavy projections alternately produced; first right, then left, from the dorsal surface of the spine; and it was in consideration of this peculiarity that the name was chosen. Even if the spine were worn or abraded, which does not appear to be the case, the great difference in the *number* of the denticles must distinguish it from *P. cylindricus*, Ag., which has six or seven times as many denticles as the spine now described.

In the original description† of the specimens forming this species attention was drawn to their resemblance to *Orthacanthus*, the principal points of difference being in the curved contour of the spine, and in the peculiar form and large size of the posterior denticles. During the following year a number of additional specimens were discovered forming intermediate stages between *Pleuracanthus* and *Orthacanthus* which led to a suggestion that the two genera should be combined along with *Xenacanthus* and *Diplodus*,‡ and all form only one genus. After considerable care in comparing specimens, it appears probable that *Phricacanthus* must be included in the genus *Pleuracanthus*. The latter now includes not only the straight spines of *Orthacanthus* type, but also the curved spines, since allocated to the genus, and so covers one of the characteristic features of *Phricacanthus;* and the denticles which are now known to be extremely varied in that genus may well embrace the double row of large, widely separated and alternate denticles of *Phricacanthus*. The specific name *biserialis* is pre-occupied, having been applied to a species of *Pleuracanthus* from the Coal Measures of Ohio by Dr. J. S. Newberry§ in 1856. It is now proposed to distinguish the species as *Pleuracanthus obtusus*, Davis.

Formation and locality.—Bone-bed above Better-bed Coal; Clifton, Yorkshire.

Ex coll.—James W. Davis, Halifax.

* Cat. Foss. Fishes, Brit. Museum, p. 8. 1889.

† Quart. Journ. Geol. Soc., vol. xxxv., p. 186. 1879.

‡ *Op. cit.*, vol. xxxvi., p. 325. 1880.

§ Proc. Acad. Nat. Sci., Philadelphia, p. 100. 1856.

Pleuracanthus serratus, sp. nov.

(Pl. lxxiii., figs. 19, 20.)

Spine: length averages 0·04; the longest example is 0·07, and the shortest 0·015. An example 0·04 in length is 0·002 in diameter at the base, and diminishes to a fine point at the distal extremity. The anterior surface is more or less circular in a section cut across the spine; the posterior surface is also rounded but to a smaller extent. A double row of denticles, twenty in number on each side, extends along the lateral posterior surface in the position shown in fig. 19. The denticulated surface extends from the point a distance of 0·025 m. towards the base. The denticles present the appearance of a series of triangular pendants, the point of each being suspended from the base of the preceding one; they are closely set, and the base, at its lowest and widest part, is equal in width to the height of the apex of the wedge-shaped denticle. The denticles are largest midway, and decrease in size both towards the distal and basal extremities.

A considerable number of these small spines have been obtained from the Lowmain Coal Seam. The posterior position of the denticles at once distinguishes them from small examples of *Pleuracanthus lævissimus*, Ag., which frequently occur in the same beds about the same size. The number of denticles is equal to that of *P. robustus* when full grown, but their form is sufficiently distinctive, and they do not fall in with any of the previously described species.

Formation and Locality.—Lowmain Coal Seam, Newsham.

Ex coll.—Atthey Collection, Museum of the Natural History Society of Northumberland and Durham at Newcastle-on-Tyne.

Pleuracanthus Woodwardi, sp. nov.

(Pl. lxxiii., fig. 21.)

Spine: length 0·25 m.; point and base imperfect; probably 0·025 must be added at distal end, equal to 0·275 m. without addition to base, or 0·3 in length if complete; base crushed; at a distance of 0·1 m. from proximal extremity the diameter is 0·015 m., from which point it tapers to the distal end. In section the spine is oval, with a flattened anterior surface. The posterior surface has a slight median ridge, and on each side, extending a distance of 0·1 m. on the part preserved (or probably 0·12 m. if it were perfect), there is a row of large,

recurved, acuminate denticles, forty-five in number. The surface of the spine is smooth or slightly striated.

This species is most nearly related to *P. lævissimus*, Ag., but the position of the denticular row is not lateral but is placed far towards the posterior surface as shown in fig. 21 *a*; the denticles are more *hooked* than in *P. lævissimus.*

The rows of denticles are, however, not nearly so closely approximated as in *P. cylindricus;* they appear to show a connecting and intermediate link between the two species, and go a long way to prove their generic identity. I have appended the specific name *Woodwardi* in recognition of the services of my friend Mr. A. Smith Woodward.

Formation and Locality.—Coal Shale, Dalkeith. Candenfoot, Dalkeith.

Ex coll.—No. P 3178*a*. Enniskillen Collection, Natural History Department, British Museum. No. P 1730. Egerton Collection, Natural History Department, British Museum.

Pleuracanthus (Lophacanthus) Taylori, Stock.

(Pl. LXXIII., figs. 22, 23.)

A spine from Airdrie (No. 42,035 in B. M. Coll.), perfect at the proximal end, but wanting the distal one, is 0·20 m. in length. It is slightly curved, 0·01 m. in diameter at the widest part, more or less circular in section, the antero-posterior diameter being greater than that between the sides, with a double row of denticles extending along the posterior surface to a distance of 0·07 m. of the base. The denticles are short, rather widely separated, slightly curved backwards. The rows of denticles are separated by a distance equal to half the diameter of the spine between the anterior and posterior surfaces. The surface is smooth or slightly ridged in wavy lines. The proximal extremity is rounded with the terminal orifice open for a short distance along the posterior surface. The internal cavity higher in the spine is small.

This spine closely resembles that of *P. cylindricus*, Ag., but has a more distinct curvature than the spine of that species, and is more especially distinguished by the wide area separating the two rows of posterior denticles.

The spine, No. P 42,035, appears to be closely related to a spine from the Low-main Coal Seam at Newcastle, at present in the Atthey collection in the Museum of Natural History. The Newcastle specimen is 0·24 m. in length, and is slightly thicker than the one in the British Museum, but in other respects is characterized by its curved outline and the position of the two rows of denticles (fig. 23).

The spine described by Mr. Thomas Stock* as *Lophacanthus Taylori* was from the Lowmain Coal Seam. The writer has not had an opportunity to inspect the original, but the woodcut with which the description is illustrated indicates a close resemblance to the spine in the Atthey collection. The section as illustrated by the woodcut, is different, but that may be perhaps accounted for by the imperfection of the specimen. The relationship between these spines being so close, I feel justified in including them under the specific name given by Mr. Stock; but as I am convinced that they are not generically distinguishable from the spines of *Pleuracanthus*, they must be included in that genus.

Formation and Locality.—Coal Measures, Airdrie; Lowmain Coal Seam, Newsham.

Ex coll.—Natural History Department, British Museum; Mr. Joseph Taylor, of Shire Moor; Museum of Natural History, Newcastle.

Pleuracanthus (Compsacanthus) triangularis, Davis.

(Pl. lxxiii., fig. 24.)

Compsacanthus triangularis, . Davis, J. W., 1880, "Quart. Journ. Geol. Soc.," vol. xxxvi., p. 62 (woodcut).

Spine: straight, robust, upper part perfect; base somewhat crushed; 0·063 m. in length; greatest diameter 0·005 m. midway between the extremities; distally it gradually contracts, and ends in a point. The base is hollow, and the walls are thin; the internal cavity apparently terminal. The lateral surfaces of the spine are compressed anteriorly, which gives it a triangular form in section. The posterior surface, from which springs a single median row of denticles, is rounded. The denticles are broad at the base, compressed laterally, ending in an obtuse point.

This spine, which still remains unique, was found in the Cannel Coal of Tingley; it was included in Dr. Newberry's genus *Compsacanthus*,† characterized by having only a single row of denticles on the posterior surface of the spine. *Compsacanthus lævis*, Newb., is circular in section, and there are a considerable number of denticles diminishing in size from the lower towards the upper part of the spine. In this species the number of denticles is small, and the spine is more or less triangular in section.

Dr. Zittel has expressed the opinion that probably *Compsacanthus* will be

* Ann. and Mag. Nat. Hist., ser. v., vol. v., p. 217.

† Proc. Acad. Nat. Sci. Philad., p. 100, 1856; Rept. Geol. Survey, Ohio, vol. i., pt. ii, p. 332, pl. xl., fig. 5, 1873.

found identical with *Orthacanthus*,* and Mr. A. Smith Woodward accepts the same view in cataloguing the fossil-fishes in the British Museum, and places the genus as a synonym of *Pleuracanthus*.†

Formation and Locality.—Middle Coal Measures, Tingley, in Yorkshire.

Ex coll.—James W. Davis, Halifax.

Pleuracanthus (Diplodus) equilateralis, Ward.

(Pl. LXXIII., fig. 27.)

Diplodus equilateralis, . . WARD, J., 1889, "Trans. N. Staffs. Inst. Mining and Mech. Engin.," vol. X., p. 139, pl. II., fig. 2.
Diplodus equilateralis, . . WOODWARD & SHERBORN, 1890, "Cat. Brit. Foss. Verteb.," p. 66.

Teeth: "Base of tooth relatively small, rounded, or oval; concave below, coarsely pitted with a strong prominent knob or heel-like projection at the anterior margin. Lateral denticles, two in number, divergent on the same plane; they are short, conical, broad for nearly their entire length, when they rapidly contract; compressed, equal in length, with their margins finely carinated. Between the two lateral denticles, at their basal junction, there is a slightly elevated boss, from which spring two intermediate denticles, equal in length, compressed, with smooth margins" (Ward).

Formation and Locality.—Shale overlying the Deepmine Ironstone, Longton, Staffordshire.

Ex coll.—John Ward, Longton.

Genus, **Anodontacanthus**, Davis.

"Quart. Journ. Geol. Soc.," 1881, vol. xxxvii., p. 427.

The spines included in this genus are straight, more or less tapering to a point. Internal cavity large, terminating at the base without posterior extension of the opening. Distinguished from *Pleuracanthus* by the absence of denticles.

* Handb. der Palæontologie, vol. iii., pt. I., p. 90. 1887.

† Cat. Foss. Fishes, pt. I., p. 2.

The genus is confined to two species from the Cannel Coal of Tingley, in Yorkshire. A single specimen described as a third species, *A. fastigiatus*,* from the Blackband Ironstone at Loanhead, in the Carboniferous Limestone series, near Edinburgh, is considered by Dr. Traquair, who has other specimens, to belong to another genus, and awaits his further elucidation.

Anodontacanthus acutus, Davis.

(Pl. lxxiii., fig. 25.)

Anodontacanthus acutus, . Davis, J. W., 1881, "Quart. Journ. Geol. Soc.," vol. xxxvii., p. 428, pl. xxii., fig. 10.

Spine: length, 0·6 m.; breadth, 0·05 m., gradually tapering to a point; straight, circular in section, with an internal cavity occupying one-half the diameter of the spine in the middle of its length; towards the base the walls become thinner; orifice terminal. There are no lateral denticles.

Formation and Locality.—Cannel Coal, Tingley.

Ex coll.—James W. Davis, Halifax.

Anodontacanthus obtusus, Davis.

(Pl. lxxiii., fig. 26).

Anodontacanthus obtusus, . Davis, J. W., 1881, "Quart. Journ. Geol. Soc.," vol. xxxvii., p. 248, pl. xxii., fig. 11.

Spine: larger than the preceding one, probably 0·9 m. in length and proportionately thick; oval in section, with the internal cavity much smaller than in *A. acutus*; distal extremity obtusely flattened and circular.

Formation and Locality.—Cannel Coal, Tingley.

Ex coll.—James W. Davis, Halifax.

* Quart. Journ. Geol. Soc., vol. xxxvii., p. 428. 1881.

PLATE LXV.

ON THE FOSSIL FISH-REMAINS OF THE COAL MEASURES OF THE BRITISH ISLANDS.—I. PLEURACANTHIDÆ.

EXPLANATION OF PLATE LXV.

Pleuracanthus (*Diplodus*) *lævissimus*, Agass.

Figure

1. Lower jaws in natural position ; reduced to half diameter.

   a. Right lower jaw, under surface. Posterior portion of jaw, apparently divided by centres of ossification into a series of plates.

   b.b. Left lower jaw. Outer margin of the two mandibles thickened by the pressure from the other side of the upper jaws.

   c.c. Terminal ossifications forming the snout, and extending between the anterior extremities of the palato-quadrates.

   d. Plate from the left posterior margin of the cranium.

   e.e. Cranial plates, probably located anteriorly to *d.*

2. Pectoral fin (natural size).

3–15. Teeth from various parts of the jaws (natural size).

Formation and Locality.—1, 3–15, Low Main Coal Seam, Newsham, Northumberland; 2. Cannel Coal, Tingley.

Ex coll.—Atthey Collection, Museum, Newcastle-on-Tyne; James W. Davis, Chevinedge, Halifax.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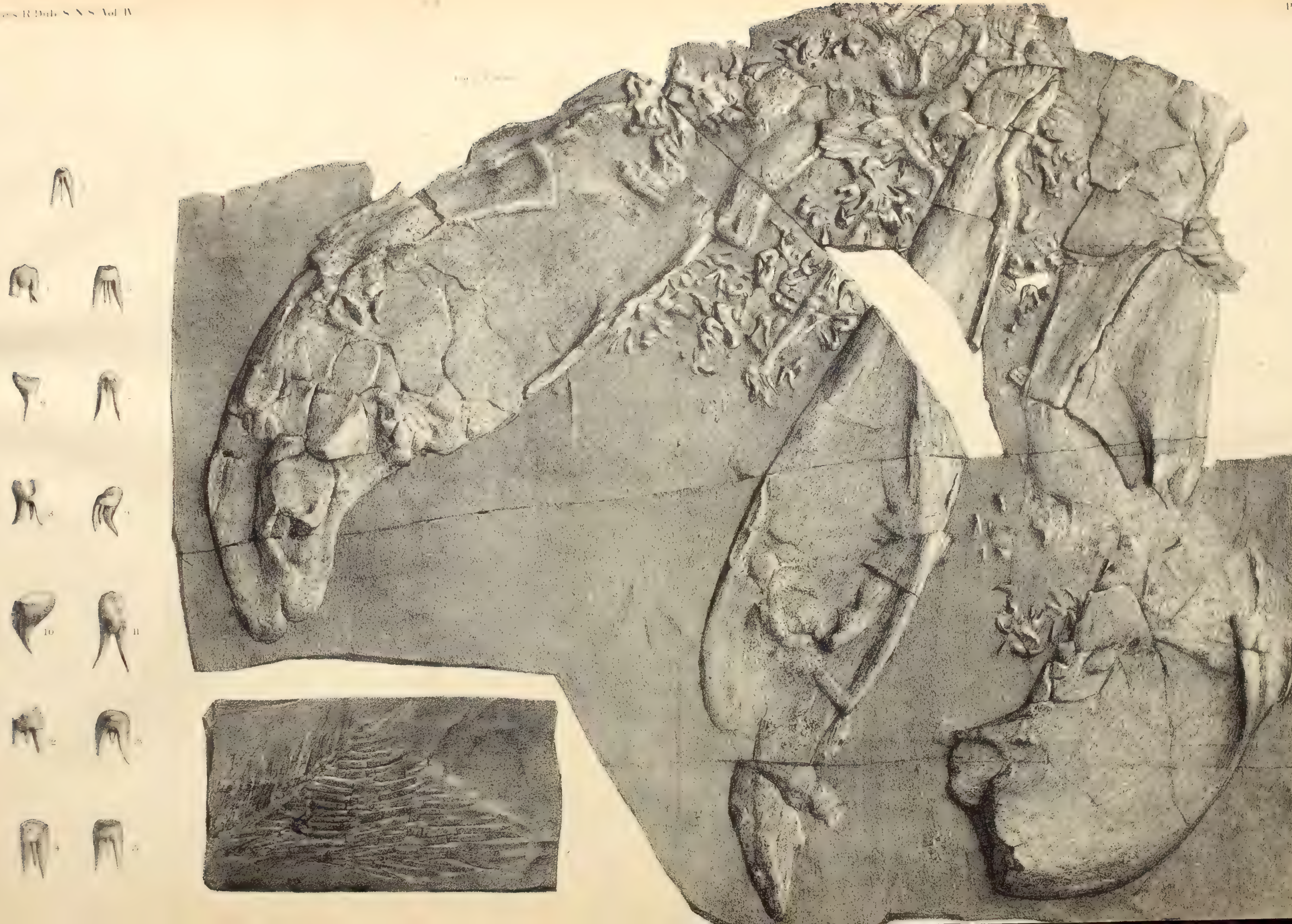


PLATE LXVI.

ON THE FOSSIL FISH-REMAINS OF THE COAL MEASURES OF THE BRITISH ISLANDS.—I. PLEURACANTHIDÆ.

EXPLANATION OF PLATE LXVI.

Pleuracanthus (*Diplodus*) *lævissimus*, Agass.

Figure

1. Upper jaws (palato-quadrates). Opposite side of specimen represented on Plate LXV. Reduced to half diameter.

   a. Right upper jaw.

   b. Left upper jaw; each with wide lateral expansion, forming osseous plates, joining along the median line of the palate.

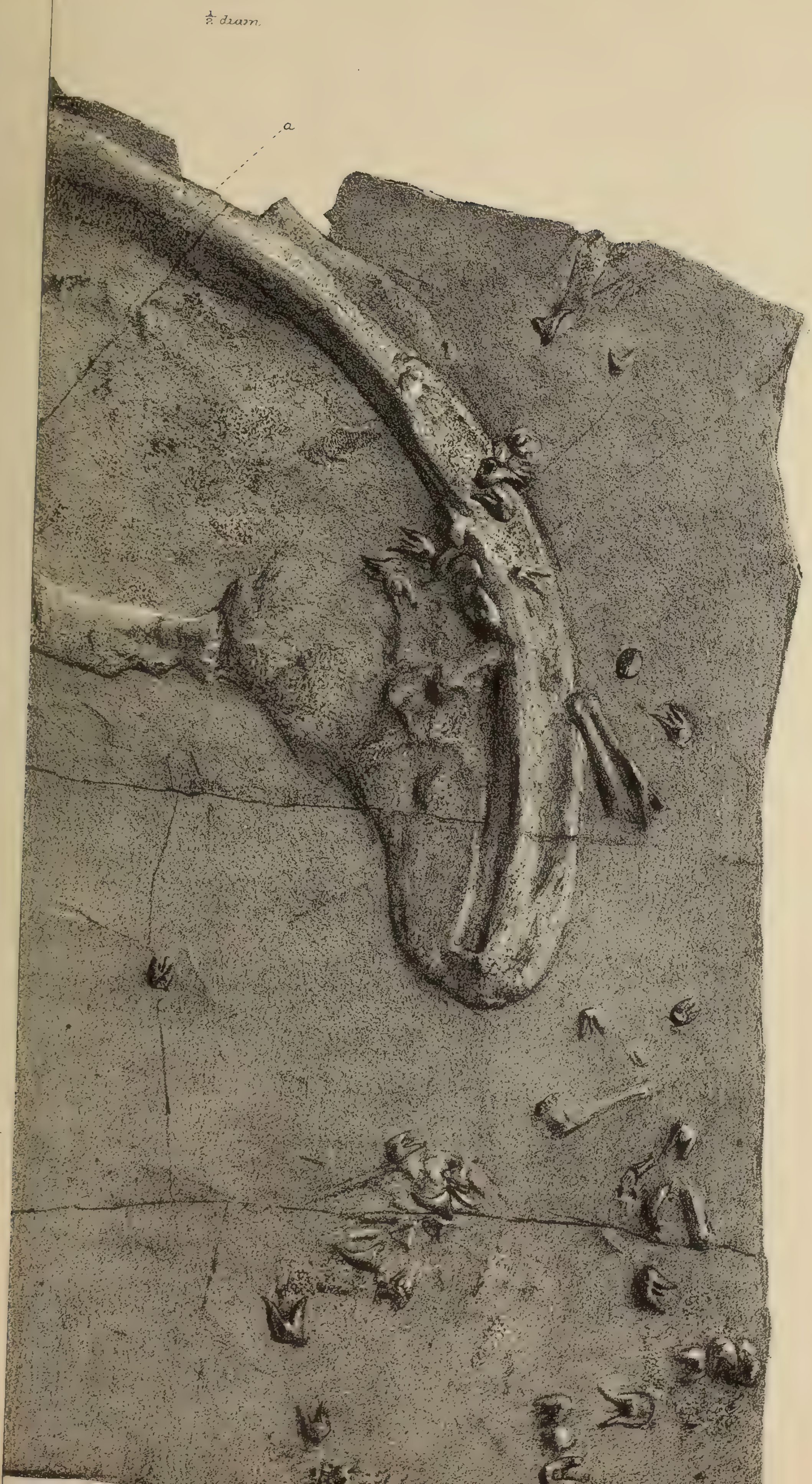
   c. Anterior extremities of palato-quadrates, to which were attached the bones of the snout (Pl. LXV., *c.c.*).

   d. Inferior surface of cranial plate exhibited on Pl. XLV.

   e.e. Inferior surface of plates indicated by same letter on Pl. LXV.

Formation and Locality.—Low Main Coal Seam, Newsham.

Ex coll.—Atthey Collection, Museum, Newcastle-on-Tyne.


½ diam.
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a

a

PLATE LXVII.

ON THE FOSSIL FISH-REMAINS OF THE COAL MEASURES OF THE BRITISH ISLANDS.—I. PLEURACANTHIDÆ.

EXPLANATION OF PLATE LXVII.

Pleuracanthus (? species).

(Natural size.)

Figure

1. Shoulder girdle, with parts of the branchial arches.

a. Left scapular arch.
b. Right scapular arch.
c. Left branchial arches.
$c._1$,, ,, ,,
$c._2$,, ,, ,,
$c._3$,, ,, ,,
$c._4$,, ,, ,,
d. Right branchial arches.
$d._1$,, ,, ,,
$d._2$,, ,, ,,
$d._3$,, ,, ,,
e. Hyomandibular bone.
f. ? Base of attachment for the spine.
g. Gill-rakers (stemmatoid ossicles) derived from the gill-arches.

Formation aud Locality.—Low Main Coal Seam, Newsham, Northumberland.

Ex coll.—Atthey Collection, Museum, Newcastle-on-Tyne.

2. Bones of upper surface of the cranium.

a. Parieto-frontal plates.
b. Occipital.
c. Lateral occipitals.
d. Postero-lateral plates, completing the posterior margin of the cranium.
e. f. Intermediate plates between the parieto-frontals and the lateral plates, *g. h.*
g. h. Lateral plates ; *g.* on the left side in fig. 2 is covered by the displaced plate *d.*
i. Anterior plates over the snout.
x. Small median hexagonal plate.
or. Orbits.

2*a*. Restoration of No. 2. The letters above apply to this figure.

3. Underside of the occipital plate.

Formation and Locality.—Low Main Coal Seam, Newsham, Northumberland.

Ex coll.—William Dinning, Newcastle-on-Tyne.

Plate LXVII.

1.

2.

3.

2 a.

J W Davis del. W. H. Crowther lith. West, Newman, imp.

PLATE LXVIII.

ON THE FOSSIL FISH-REMAINS OF THE COAL MEASURES OF THE BRITISH ISLANDS.—I. PLEURACANTHIDÆ.

EXPLANATION OF PLATE LXVIII.

Pleuracanthus (? species).

(All figures natural size.)

Figure

1. Right lower jaw. Internal surface.

1*a*. ,, ,, ,, External surface.

2. Articulating extremity of lower jaw.

3. The same of another specimen.

   a. Articulating process.
   b. Angular bone.
   c. Dentary bone.

4. *Pleuracanthus* (*Diplodus*) *lævissimus*, Agass. Exhibiting the serial arrangement of the teeth.

   a. Teeth of upper jaw.
   b. Teeth of lower jaw.

5, 5*a*. Osseous fragment, with articulating surface.

6. Another example, with articulating extremity.

7. Osseous plate.

8. Occipital plate.

9. Pterygopodium (clasper) of the ventral fin.

   a. Clasper.

10. Pterygopodium, (?).

Formation and Locality.—All except fig. 4 from Low Main Coal Seam, Newsham. Fig. 4, Thin Bed Coal, Burnley, Lancashire.

Ex coll.—Figs. 1, 2, 5, 6, 7, 8, 9, W. Dinning, Newcastle-on-Tyne; fig. 3, Atthey Collection, Museum, Newcastle-on-Tyne; fig. 4, George Wild, Bardsley, Lancashire.

J.W.Davis dir W.H.Crowther lith

PLATE LXIX.

ON THE FOSSIL FISH-REMAINS OF THE COAL MEASURES OF THE BRITISH ISLANDS.—I. PLEURACANTHIDÆ.

EXPLANATION OF PLATE LXIX.

Pleuracanthus (*Diplodus*) *lævissimus*, Agass.

(Reduced to half diameter.)

a. Right ramus of lower jaw.

a.' Articulatory surface.

b. Anterior extremity of left ramus of lower jaw.

c. Dentary surface, with teeth.

d. Extremity of the palato-quadrate.

e., *f.* I., II., III., IV. Bones of the branchial arches.

g. Detached gill-rakers.

Formation and Locality.—Low Main Coal Seam, Newsham, Northumberland.

Ex coll.—Atthey Collection, Museum, Newcastle-on-Tyne,

W. Davis dir W H Crowther lith.
West, Newman imp.

PLATE LXX.

ON THE FOSSIL FISH-REMAINS OF THE COAL MEASURES OF THE BRITISH ISLANDS.—I. PLEURACANTHIDÆ.

[EXPLANATION OF PLATE LXX.

Pleuracanthus (*Diplodus*) *lævissimus*, Agass.

Figure

1. Head considerably crushed, with spine (natural size).

    a. Right ramus of lower jaw, showing arrangement of teeth *in situ.*

    b. Lower jaw ; left ramus.

    c. ? Hyomandibular.

    d. d. Cranial plates.

    e. Spine.

2–9. Examples of so-called " Stemmatodus " (enlarged).

Formation and ocality.—Low Main Coal Seam, Newsham, Northumberland.

Ex coll.—Atthey Collection, Museum of Natural History, Newcastle-on-Tyne.

Plate LXX.

J.W Davis dir WH Cro

PLATE LXXI.

ON THE FOSSIL FISH-REMAINS OF THE COAL MEASURES OF THE BRITISH ISLANDS.—I. PLEURACANTHIDÆ.

EXPLANATION OF PLATE LXXI.

Figure

1. *Pleuracanthus* (*Diplodus*) *lævissimus*, Agass., exhibiting the posterior part of the head, together with spinous bones of the hæmal or neural arches, and inter-spinous bones. (Reduced to half diameter.)

   a. Lower jaw.

   b. b. Cranial plates dissociated.

   c. Vertebral spines (? neural), with enlarged base.

   d. Inter-spinous rays.

   e. Surapophysial ray.

   t. Teeth.

2. Inter-spinous ray. Natural size.

3. ,, ,, ,

4. Surapophysial ray. ,,

5. Teeth. Enlarged.

Formation aud Locality.—Low Main Coal Seam, Newsham, Northumberland.

Ex coll.—William Dinning, Newcastle.

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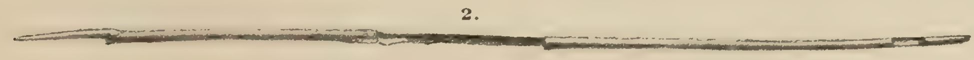

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J. W. Davis dir. W. H Crowther lith. West Newman, imp

PLATE LXXII.

ON THE FOSSIL FISH-REMAINS OF THE COAL MEASURES OF THE BRITISH ISLANDS.—I. PLEURACANTHIDÆ.

EXPLANATION OF PLATE LXXII.

Figure

1. *Pleuracanthus lævissimus*, Agass.

3–9. *Pleuracanthus lævissimus*, Agass.

1. Ragmine Ironstone, Fenton. *Ex coll.*—John Ward.
3. Cannel Coal, Tingley. *Ex coll.*—James W. Davis.
4, 5. Arley Mine, Burnley. *Ex coll.*—George Wild.
6, 7. Lowmain Coal, Newsham. *Ex coll.*—Newcastle Museum.
8. Shattleston, Glasgow. *Ex coll.*— James Thomson.

2. *Pleuracanthus cylindricus*, Agass. Fenton, Staffordshire. *Ex coll.*—P. 6692, British (Natura History) Museum.

10–14. *Pleuracanthus robustus*, Davis.

10, 11, 14. Cannel Coal, Tingley. *Ex coll.*—James W. Davis.
12. Knowles Ironstone Shale, Fenton. *Ex coll.*—John Ward.
13. Lowmain Coal, Newsham. *Ex coll.*—Newcastle Museum.

15. *Pleuracanthus Wardi*, Davis. Ragmine Ironstone, Fenton. *Ex coll.*— John Ward.

16. *Pleuracanthus undulatus*, Davis. Thin-bed Coal, Burnley. *Ex coll.*—G. Wild, Manchester Museum.

17. *Pleuracanthus tenuis*, Davis. Better-bed Coal, Yorkshire. *Ex coll.*—James W. Davis.

18–20. *Pleuracanthus denticulatus*, Davis.

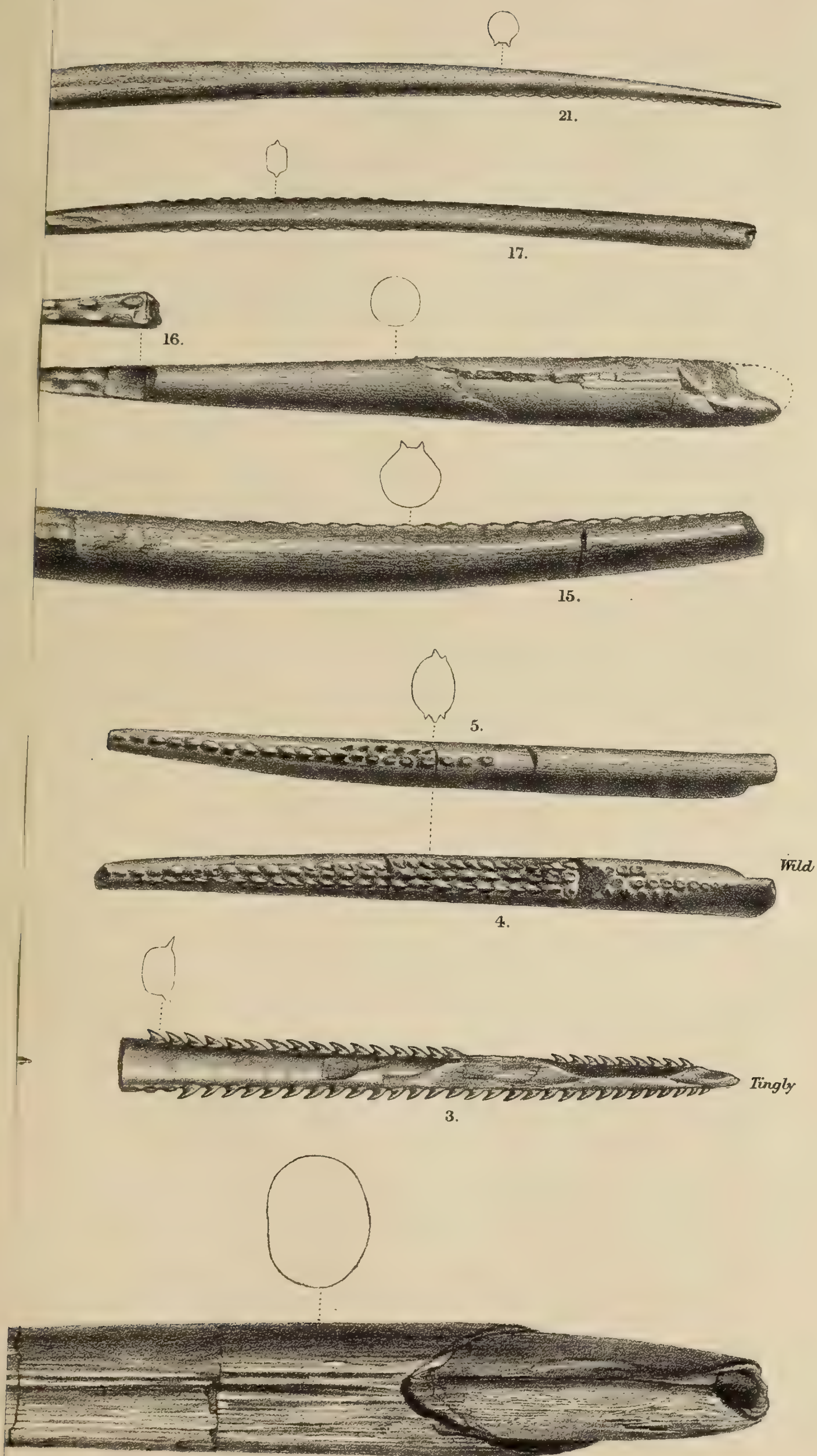
18. Better-bed Coal, Yorkshire. *Ex coll.*—James W. Davis.
19. Lowmain Coal, Newsham. *Ex coll.*—Newcastle Museum.
20. Bardsley, Lancashire. *Ex coll.*—George Wild.

21. *Pleuracanthus Howsei*, Davis. Lowmain Coal, Newsham. *Ex coll.*—Newcastle Museum.

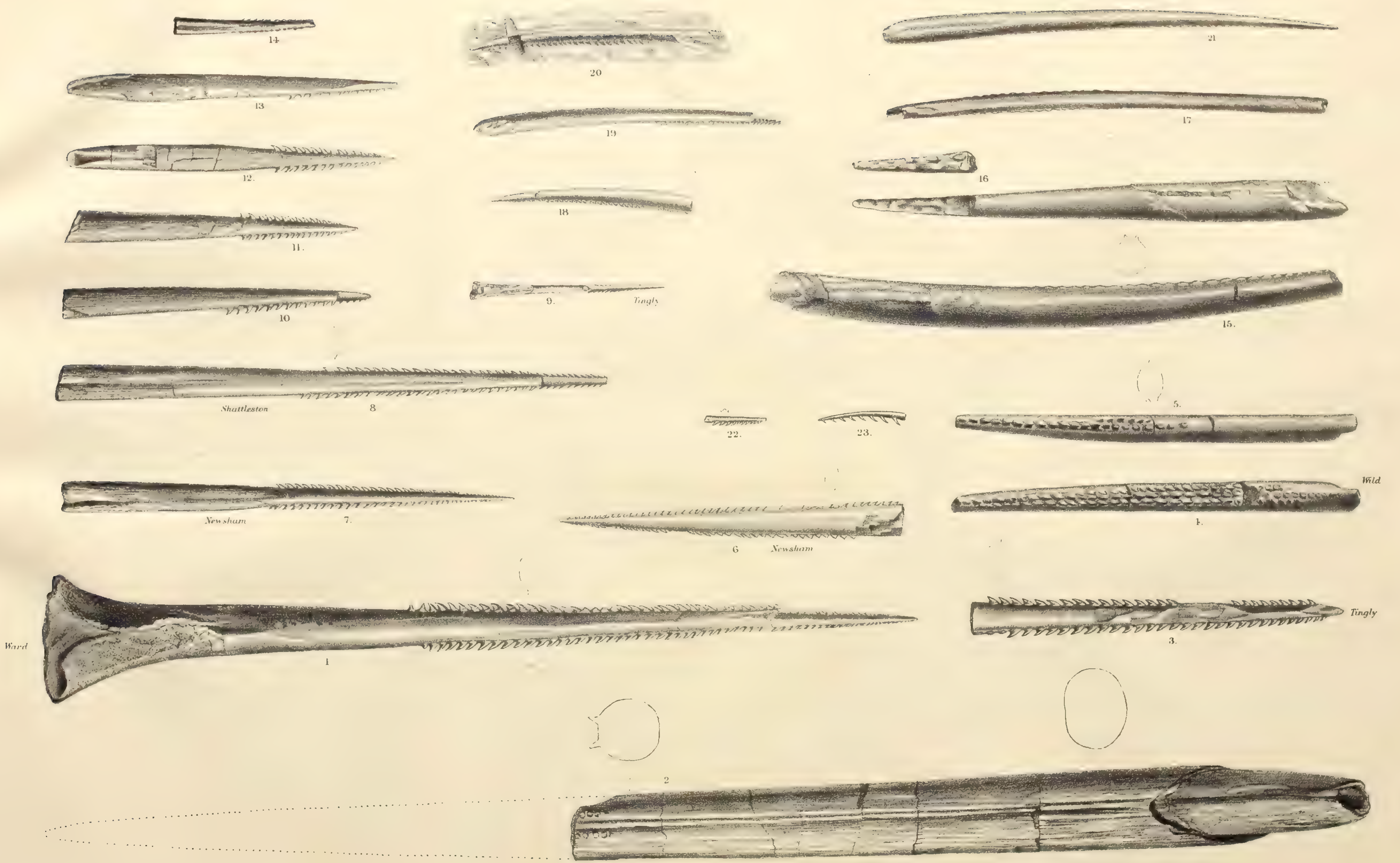
22, 23. *Pleuracanthus horridulus*, Traq. Better-bed Coal, Clifton, Yorkshire. *Ex coll.*—James W. Davis.

N.B.—Fig. 2 in this Plate has been drawn by mistake instead of the specimen of *P. lævissimus*, referred to in the text.

Plate LXXII.



West, Newman, imp



West, Newman, imp.

PLATE LXXIII.

ON THE FOSSIL FISH-REMAINS OF THE COAL MEASURES OF THE BRITISH ISLANDS.—I. PLEURACANTHIDÆ.

EXPLANATION OF PLATE LXXIII.

Figure

1–4. *Pleuracanthus cylindricus* (Agassiz), Davis.

1. Ragmine Ironstone, Fenton. *Ex coll.*—John Ward.
2. ? *Ex coll.*—P. 1735, British (Natural History) Museum.
3. Knowles Ironstone, Longton. *Ex coll.*—John Ward.
4. Quarter Hamilton, Scotland. *Ex coll.*—James Thomson.

5–13. *Pleuracanthus alatus*, Davis.

5. Tingley, Yorkshire. *Ex coll.*—James W. Davis.
6. Middleton, Yorkshire. *Ex coll.*—Museum, Leeds.
7–9. Deepmine Shale, Longton. *Ex coll.*—John Ward.
10–12. Lowmain, Newsham. *Ex coll.*—Newcastle Museum.
13. Quarter Hamilton, near Glasgow. *Ex coll.*—James Thomson.

14–16. *Pleuracanthus erectus*, Davis.

14. Lowmain, Newsham. *Ex coll.*—Newcastle Museum.
15, 16. Cannel Coal, Tingley. *Ex coll.*—James W. Davis.

17. *Pleuracanthus Thomsoni*, Davis. Quarter Hamilton, Kilmarnock. *Ex coll.*—James Thomson.

18. *Pleuracanthus obtusus*, Davis. Better-bed Coal, Clifton, Yorkshire. *Ex coll.*—James W. Davis.

19, 20. *Pleuracanthus serratus*, Davis. Lowmain Coal, Newsham. *Ex coll.*—Newcastle Museum.

21. *Pleuracanthus Woodwardi*, Davis. Candenfoot, Dalkeith. *Ex coll.*—P. 3178, British (Natural History) Museum.

22, 23. *Pleuracanthus Taylori* (Stock), Davis.

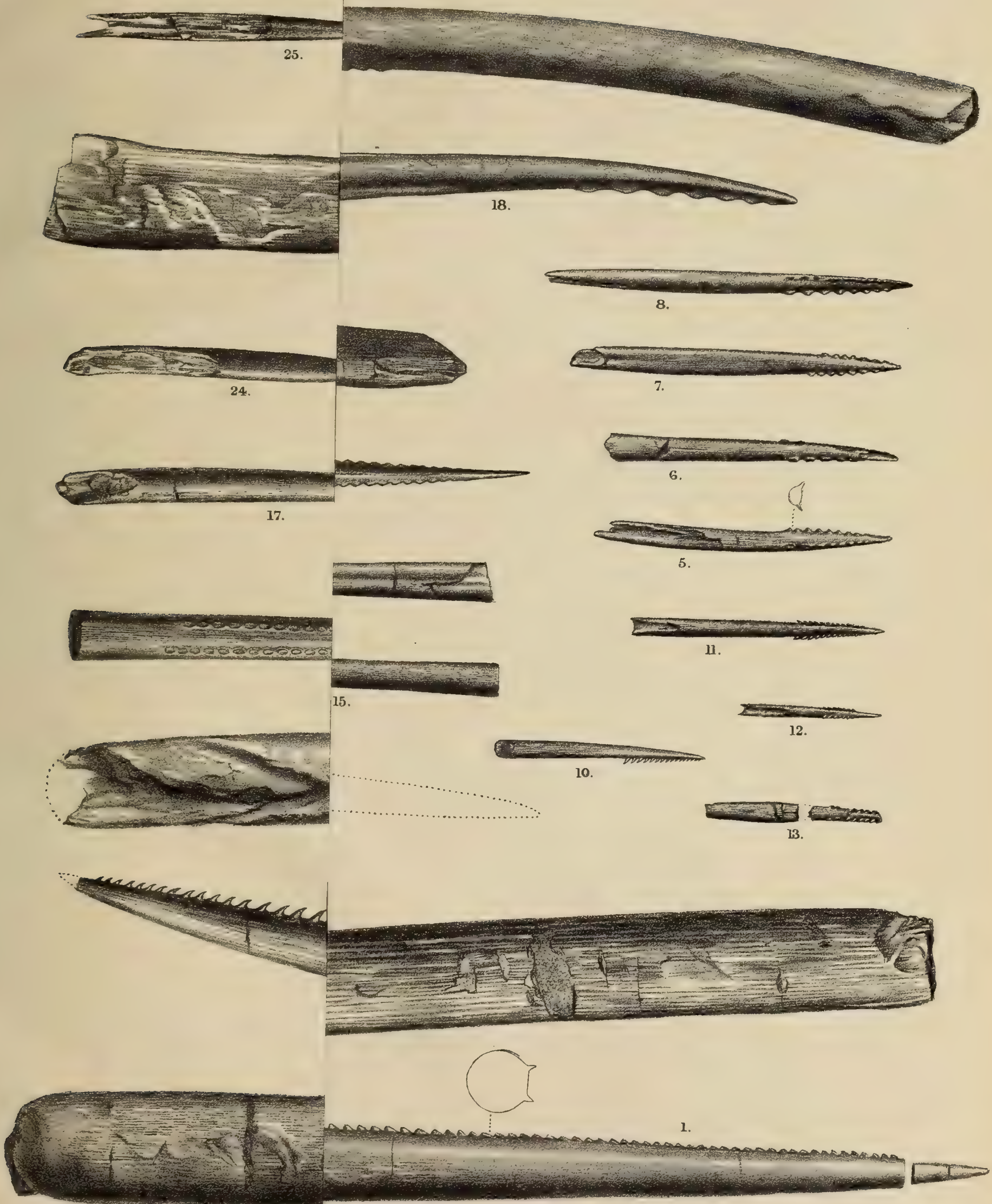
22. Coal Measures, Airdrie. *Ex coll.*—No. 42,035, British (Natural History) Museum.
23. Lowmain Coal, Newsham. *Ex coll.*—Newcastle Museum.

24. *Pleuracanthus triangularis*, Davis. Tingley, Yorkshire. *Ex coll.*—James W. Davis.

25. *Anodontacanthus acutus*, Davis. Cannel Coal, Tingley, Yorkshire. *Ex coll.*—James W. Davis.

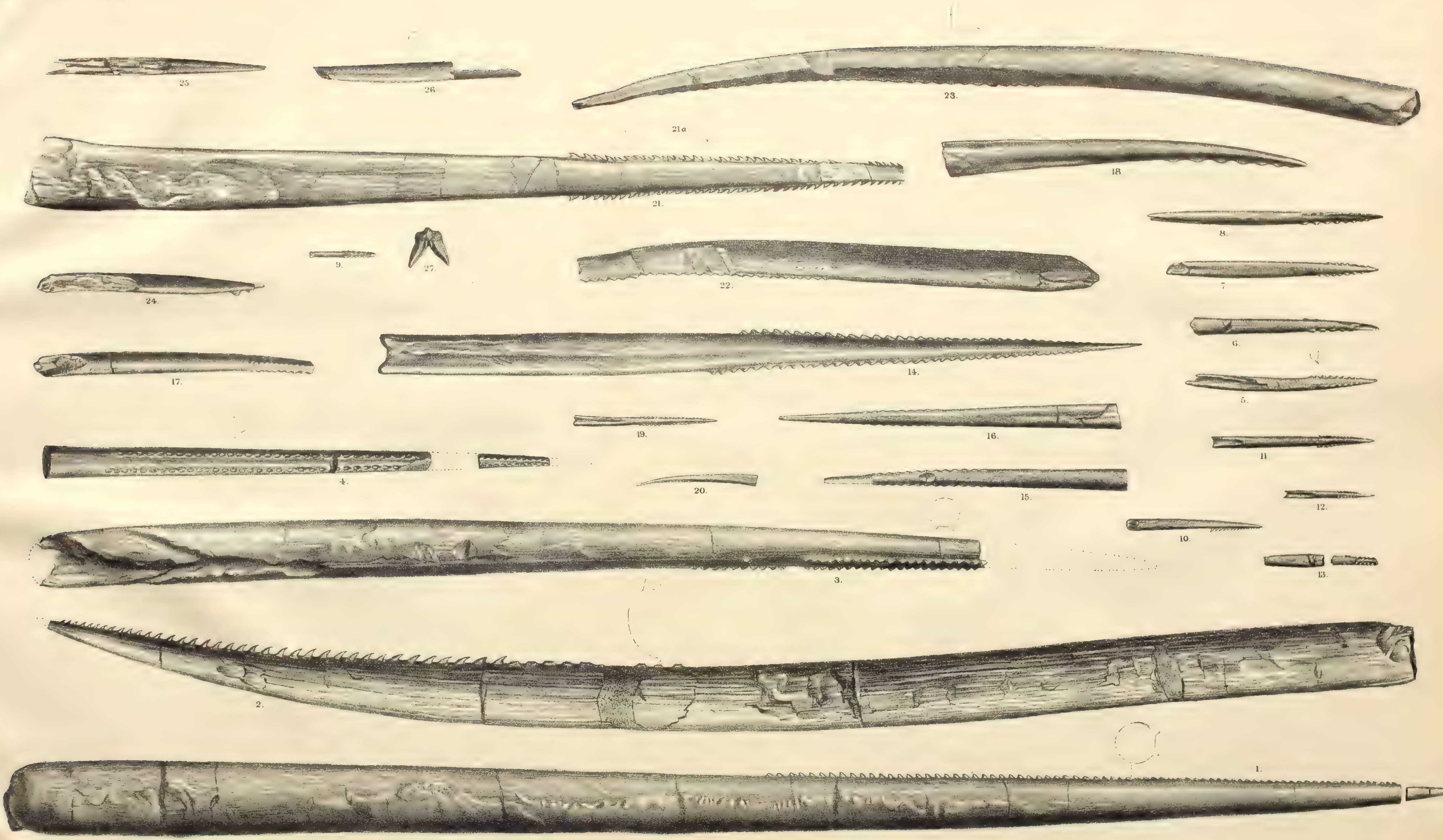
26. *Anodontacanthus obtusus*, Davis. Cannel Coal, Tingley. *Ex coll.*—James W. Davis.

27. *Pleuracanthus* (*Diplodus*) *equilateralis*, Ward. Deepmine Ironstone, Longton. *Ex coll.*—John Ward.



J. W. Davis dir. W. H. Crowther. lith.

West, Newman, imp.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